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THE KERN RIVER COMPANY'S HYDRO-ELECTRIC POWER ENTERPRISE.

By Burr Bassell,* M. Am. Soc. C. E.

The Kern River Co., of Los Angeles, Cal., is at present constructing a large hydro-electric plant on the Kern River, in Kern County, Cal. The power furnished by this stream will be electrically transmitted 120 miles, over mountain, desert and plain to Los Angeles, and there utilized by the

Fig. 1. Diverting Overflow Weir Under Construction.

Pacific Light and Power Co., locally known as the "Hellman-Huntington Syndicate."

There are several large power plants and long transmission lines being constructed on the Pacific Slope, but none known to the writer of greater interest than the one now briefly described.

The entire flow of the North Fork of the Kern River will be diverted near Kernville, and carried in a canal 11½ miles in length to the power house situated on the river below. The minimum discharge at the point of diversion is about 200 cu. ft. per second, while the average annual discharge is more than four times this amount. The canal has a capacity of 600 cu. ft. of water per second.

HEAD-WORKS.—The diverting dam is a substantial wooden structure, built in two sections at the up-stream end of a low island in the river valley. One section consists of ten 6-ft. gates with stop-planks, for regulating the amount of water entering the settling basin leading to the canal. The other section is a low weir, also provided with stop-planks for diverting the low-water flow, and yet so constructed as to permit the flood-water to pass over unobstructed.

The settling-basin is an elongated channel about 3,200 ft. in length, averaging 400 ft. in width and 10 ft. deep. This basin will hold ¼ million cu. ft. of silt below the grade of the canal and impound 4 million cu. ft. of water. The basin is formed by means of an artificial embankment or dike on the lower side, and when full will cover 19 acres. This dike is rip-rapped with rock on the outer slope and puddled with clay on the inner slope.

About midway between the diverting dam and the head-gates of the canal, there is built an overflow dam or regulator, 224 ft. in length and 11 ft. high.

The head-gates proper of the canal are enclosed between concrete-masonry wings. There are six gates, each 5 ft. in width, operated by rack and pinion from a platform above them. Adjoining the head-gates is a waste-way provided with nine sluice-gates for discharging silt and sand back into the river channel. These sluice-gates are placed 3 ft. below the canal grade. This structure is also provided with stop-planks and overflow regulating devices.

CANAL.—For the first eight miles the canal is 22 ft. wide on the bottom, 49 ft. at the top and 9 ft. deep, with side slopes 1½ on 1. The embankments are 10 ft. wide with outer slope 1½ on 1. The grade of the canal is 1 ft. fall per 5,000 ft.

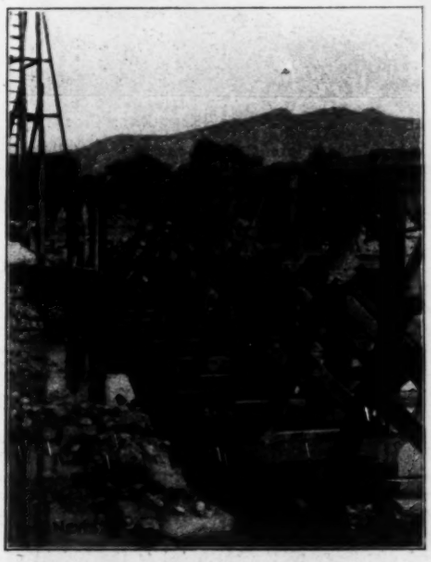

Fig. 2. Framework of Diverting Dam.

When carrying 600 cu. ft. per sec. the water will be 7½ ft. deep and will have a mean velocity of 2½ ft. per second. In rock cuts the slopes of the canal are made 1 on 1. Through sandy soil and wherever leakage may occur, the canal is being lined with cement-concrete. The last two miles of the canal is given a bottom width of 15 ft. and a grade of 2 ft. per 5,000 ft.

There are four tunnels on the line, aggregating 1,922 ft. in length and 14 flumes aggregating 5,572 ft. The tunnels are lined with cement-concrete, and have a water-way 10 ft. wide and 8 ft. deep, with a grade of 1 ft. per 1,000 ft.

The flumes on the upper division are 16 ft. wide and 8 ft. deep, having the same grade as the canal. On the lower division they are 14 ft. in width. The flume-headings are 12 ft. in length,

Fig. 3. Canal Excavation.

with both concrete and wooden wings extending into the embankments.

The most imposing structure on the line of the canal is the Kern River crossing, 1835 ft. in length. This crossing has 1,371 lineal ft. of trestle and a bridge of four spans, 484 ft. in length, carrying a flume 10 ft. wide and 8 ft. deep. This flume has a grade of 1 ft. per 1,000 ft. The bridge is of the combination type, with trusses 18 ft. apart and 29 ft. deep. The concrete piers supporting the bridge are built on bed rock which was here found to be about 15 ft. below the surface of the ground. The top of the flume is 72 ft. above the water in the river. At the upper end of the Kern River Crossing there is a reducing flume 45 ft. in length, and immediately below, a waste-way for emptying the canal into the river.

An interesting detail of construction is the manner of insuring water-tightness in the flumes. Instead of the battens commonly used for this purpose, all joints are beveled so as to admit calking with oakum and filling with asphaltum. At the sides a beaded batten is nailed below the joint into which the hot asphalt is poured and left to harden.

The fore-bay at the end of the canal is situated on a steep mountain side, and is merely an enlargement of the canal, blasted out of the rock, with a waste-way discharging into a ravine lead-

*Resident Engineer, Kern River Co., Kernville, Cal.

ing into the river below the power house. The fore-bay will be provided with sand-box, screen, weir and sluice-gates.

The following estimated data may be of interest to scientific and professional readers for comparing with experimental data to be given at a subsequent time.

Average velocity in upper division of canal,			2.50 ft. per sec.
" " " lower " " "			3.33 " " "
" " " 16-ft. flume			4.38 " " "
" " " 14-ft. "			5.76 " " "
" " " 10-ft. "			8.18 " " "
" " " tunnels			8.27 " " "

Fig. 4. A 29-ft. Cutting for the Canal.

Total time for water to pass from head-gates to fore-bay, 6 hours and 20 minutes.

Five steel riveted pressure pipes, 60 ins. in diameter and 550 ft. in length, convey the water from the fore-bay to five water-wheel units. Each unit consists of one 66-in. high pressure Victor wheel, discharging into a draft tube 25 ft. in length. The spider carrying the runners is bolted direct to the end of the flanged generator shaft. The runners are of high-pressure design, cast in one piece.

There are two 20-in. high-pressure Victor water wheels for driving the exciters, five 48-in. hydraulic water gates with by-passes, five relief valves and five Lombard "Type B" governors.

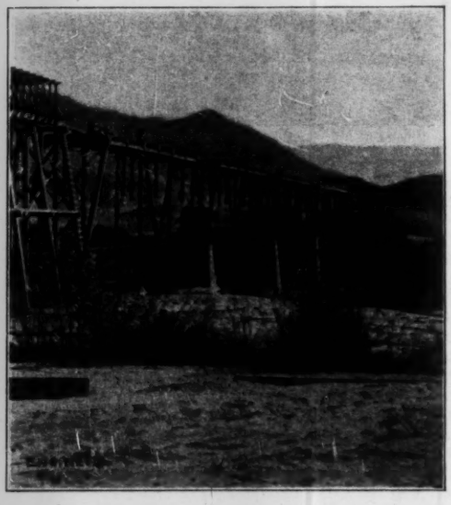

Fig. 5. Kern River Bridge Under Construction.

The turbines have an effective head of about 260 ft., including 22 ft. in the draft tubes. The power house is 168 ft. 3 ins. long by 63 ft. 10 in. wide, founded on granite bed-rock, with walls of cement, concrete and corrugated iron roof.

Gen. Charles Forman is President of the Kern River Company; Mr. A. C. Balch, General Manager; Mr. G. O. Newman, Chief Engineer, and the writer and Mr. T. M. Shaw are Resident Engineers in charge of construction.

SOME OBSERVATIONS ON STREET PAVEMENTS.

By S. Whinery,* M. Am. Soc. C. E.

XI.

A Cheap Pavement.

The article in Engineering News of May 12, 1904, describing a macadam pavement with concrete foundation, to be laid in Athens, Pa., supplies the text for a short article upon a pavement of low first cost which the writer has, for some time, believed to be worthy of careful trial.

There is quite a wide gap, both in quality and cost, between a first-class macadam road and the next available higher grade pavement, which we may assume to be vitrified brick upon a sand or gravel foundation. There is room in this gap for a street or road surface, on streets having comparatively light travel, that shall be more durable and satisfactory in use than the best macadam, and less expensive to construct than a serviceable brick pavement upon the cheapest adequate foundation.

The writer believes it is possible to design a pavement that will give excellent service and will yet be so low in first cost of construction and cost of maintenance as to bring it within the reach of villages and country road organizations where first cost must necessarily be a controlling consideration.

If the designer of the pavement ot Athens, Pa., referred to above, had substituted for the four

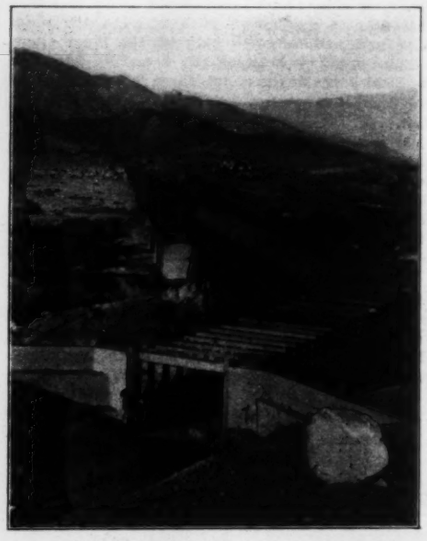

Fig. 6. General View of Kern River Crossing.

inches of macadam surface a surface of 2 ins. of strong Portland concrete, he would have embodied the general idea that the writer has in mind.

Few people who have not had favorable opportunities for observation realize the great sustaining capacity of a good concrete street foundation of very moderate thickness. There are not a few instances where, by the leaking of water mains or similar causes, the earth has been washed out from under a considerable area of the concrete foundation of a street pavement, which has continued to carry a very heavy travel for weeks and months after the washout occurred and before it was discovered. Laid upon reasonably firm earth well rolled, a good 4-in. concrete foundation will safely carry the travel of the great majority of paved streets. Such a foundation, therefore, fulfills the first requirement of a satisfactory street pavement—strength to support and distribute to the earth below the weight of vehicles passing over it. The second requirement—a wearing surface that will resist the crushing and abrading action of the wheels of vehicles and the feet of horses, is next to be provided.

Our experience with concrete as a wearing surface for streets is not very large, but in the comparatively few instances where it has been used the results indicate that it may be expected to

*Consulting Engineer, 95 Liberty St., New York city.

give quite satisfactory service.† It is not as uncommon as it should be to see the concrete foundation of an asphalt pavement, where the asphalt surface has disintegrated, exposed for considerable periods of time to the direct wear and tear of heavy travel, and most observers have, doubtless, like the writer, been surprised at the endurance of the concrete under such trying conditions. Whatever experience we may have had, or whatever preconceived notions we may have formed upon the subject, it will be readily conceded that good concrete should prove far more

Fig. 7. A High Trestle on the Flume Line.

durable as a street surface than the best macadam, and it will doubtless be further conceded that the ratio of endurance of the two materials should be much higher than the ratio of their cost.

The trial is, therefore, confidently suggested by the writer of a pavement for streets and roads of moderate travel, such as the residence streets of towns and the smaller cities, constructed as follows:

The street to be excavated to such a depth that after rolling with a ten-ton road roller, the surface will be 6 ins. below and parallel to the designed surface of the finished pavement. Upon the surface so prepared construct a concrete pavement 6 ins. thick, composed of two layers, but so combined as to be monolithic. The first layer, 4 ins. in thickness (after compression), to be of Portland cement concrete not richer than 1:3:7, if gravel of assorted sizes or crushed stone

Fig. 8. Puddling the Canal Berme.

from which only the dust has been screened be used. This concrete to be properly mixed (rather wet), placed upon the prepared street surface, graded to a depth which, after ramming, will be 4 ins., and compacted by ramming in the customary way. The second layer, 2 ins. in thickness (after compression), to be placed immediately following the first, and before the concrete in the

†See description of a concrete pavement in Bellefontaine, Ohio, in Engineering News of Jan. 3, 1895, and Jan. 7, 1904.

first has begun to set. This surface course to be composed of selected materials used in such ratios that the cement when made neat into mortar shall somewhat more than fill the voids in the sand, and that the mortar of sand and cement shall somewhat more than fill the voids in the stone or gravel. These ratios should preferably be determined by experiment. The surplus over voids may be in each case 5%. Thus, if the volume of voids in the sand when thoroughly shaken down be 35%, the volume of neat cement mortar may be 40% of the volume of the sand, and if the voids in the stone or gravel after being well compacted by shaking and ramming be 40%, the volume of the mortar of sand and cement may be 45% of the volume of the stone.

FIGS. 9 AND 10. PLACING CONCRETE LINING TO CANAL IN SANDY SOIL.

The percentages of voids in sand and stone used for concrete probably average about as here stated, and since loose Portland cement, when made neat into mortar, shrinks to about 80% of its volume, the ratios determined as above will ordinarily be, (reversing the usual order), stone or gravel 100, sand 45, and loose cement 22½, corresponding, as usually stated, quite closely to a ratio of 1:2:4.

Concrete thus compounded should possess great firmness and strength, and should be practically, though not absolutely, impermeable to water. It should be mixed quite wet, and should be immediately placed upon the green concrete of the base, well rammed, and then rolled with a hand roller not less than 3 ft. in diameter, and 30 ins. in length, weighing not less than 35 lbs. per in. of length, to complete the compacting and to give a finished surface. A 2½-ton steam asphalt roller would be preferable if care were taken to operate it closely behind the rammers, so as to complete the work before the concrete begins to set. The wearing quality of this surface layer would obviously depend largely upon the quality of the stone or gravel aggregate. Quartz gravel of assorted sizes, having all sand screened out, is probably the very best material for the purpose, but where trap or other very hard rock is available, it would be almost if not quite as good. It should be screened to take out all fragments that will not pass a screen with 1½-in. circular perforations, or that will pass a wire screen having 1-6-in. square openings. Care should be taken to have the fragments uniformly mixed in the mass—the large and small fragments are likely to separate into masses by themselves in hauling and handling.

The pavement could not, of course, be opened to travel until the concrete has become thoroughly set, which would be not less than 30 days, even where the quicker-setting Portland cements are used, and the surface should be further protected even then by spreading over it a layer of sand 1 in. thick to partly shield the surface from direct contact with the travel for a considerably longer period. The concrete should be kept quite damp during this whole period.

The cost of a pavement thus constructed may be closely estimated. Assuming the cost of materials to be, on the street:

Crushed stone or gravel for base course, per cu. yd.	$1.20
Crushed stone or gravel for top course, per cu. yd.	1.50
Sand, per cu. yd.	.80
Portland cement, per bbl.	2.20
Common labor, per day	1.75
Cost of Base Course, 1:3:7.	
1 cu. yd. of stone	$1.20
3-7-cu. yd. sand, at 80 cts.	.34
1 bbl. Portland cement	2.20
Labor, mixing and placing	.70
Sundries, water, etc.	.06
Total for 1 cu. yd.	$4.50
This would make 9 sq. yds. of base, costing, per sq. yd.	.50
Cost of Surface Course, 1:2:4.	
1 cu. yd. of stone or gravel	$1.50
¼-cu. yd. of sand, at 80 cts.	.40
1½ bbls. cement, at $2.20	3.30
Labor, mixing and placing	.90
Sundries, water, etc.	.06
Total for 1 cu. yd.	$6.16
This would make about 18 sq. yds. of 2-in. surface, costing, per sq. yd.	$.35
Making the total cost of the concrete pavement, per sq. yd.	.85

If we add to this the cost of excavating and rolling the sub-foundation, say 12 cts. per sq. yd., and the cost of the 1-in. covering of sand, say 5 cts. per sq. yd., we shall have a total of $1, and adding to this 20% for general expenses, use of tools and profit, we shall have as the total cost of the pavement complete $1.20 per sq. yd.

These figures are liberal, and such a pavement could probably be constructed by contract in most cities where proper material is available at a price not exceeding $1.15 per sq. yd., which does not greatly exceed the usual cost of the best class of macadam road.

At this price a paved roadway 18 ft. wide would cost a little over $12,000 per mile.

As compared with the best quality of macadam roadway, this pavement should possess the following advantages:

(1) Its durability should be much greater, probably 2½ to 3 times as great.

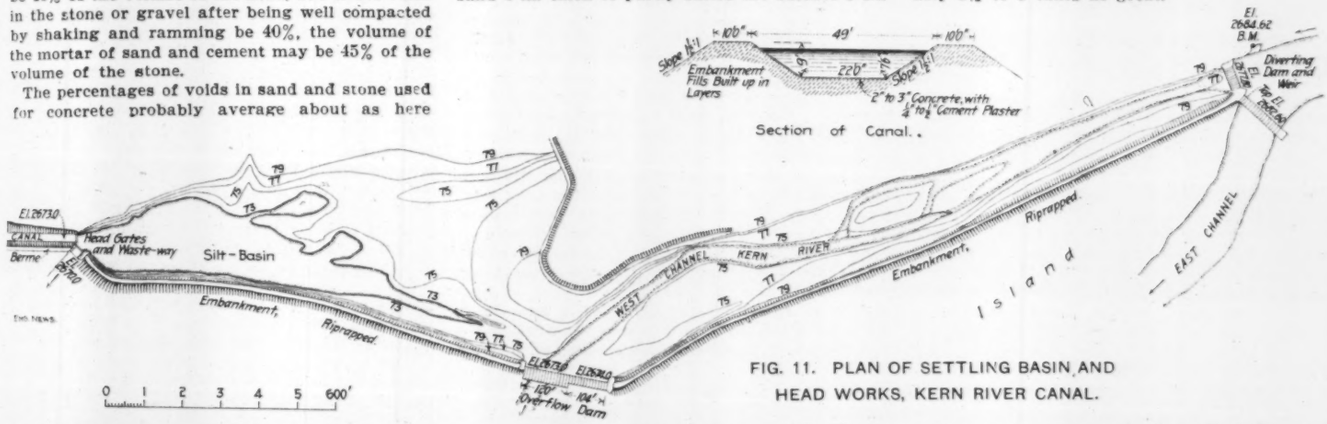

FIG. 11. PLAN OF SETTLING BASIN AND HEAD WORKS, KERN RIVER CANAL.

(2) The cost of maintaining it should not exceed one-half or one-third that of the macadam road.

(3) It should be very much less dusty, since the quantity of material abraded and reduced to dust should be very much less.

(4) Its surface should be more firm and even

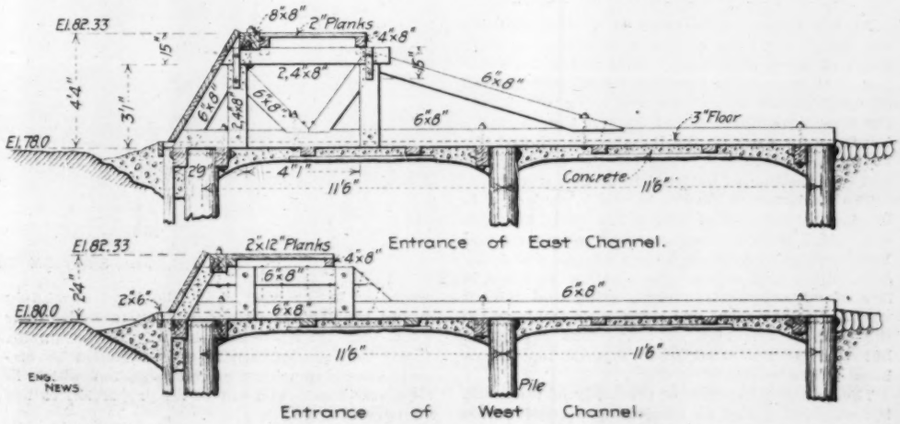

FIG. 12. SECTIONS OF DIVERTING WEIR.

than macadam, and yet offer a secure foothold for horses, and it should, therefore, be more pleasant and satisfactory to drive over.

(5) It could be cleaned with greater facility and at less cost.

The disadvantages that might be claimed are:

(1) Its slightly greater first cost.

(2) The longer obstruction to travel to allow the concrete to become properly set before the street is opened. It cannot be denied that this is a serious objection, and that it would result in no little inconvenience.

(3) The dust arising from it might be unpleasant and deleterious to health, because of the cement in its composition. But Portland cement contains but little free lime or other substances deleterious to health, and the dust from it being practically a neutral substance should not be more disagreeable to the lungs or the eyes than ordinary street dust.

(4) It would not have the same degree of elasticity as macadam, and therefore would be harder upon horses driven over it. To this it may be replied that it would be not less elastic than brick or asphalt pavement, neither of which have been found seriously objectionable in this respect.

(5) It could not be so readily repaired as macadam. On the other hand, even if this be true, the repairs when made would be of a much more durable character.

It would seem, from the above considerations, that such a pavement ought to possess much positive merit, and that it is well worth a fair trial.

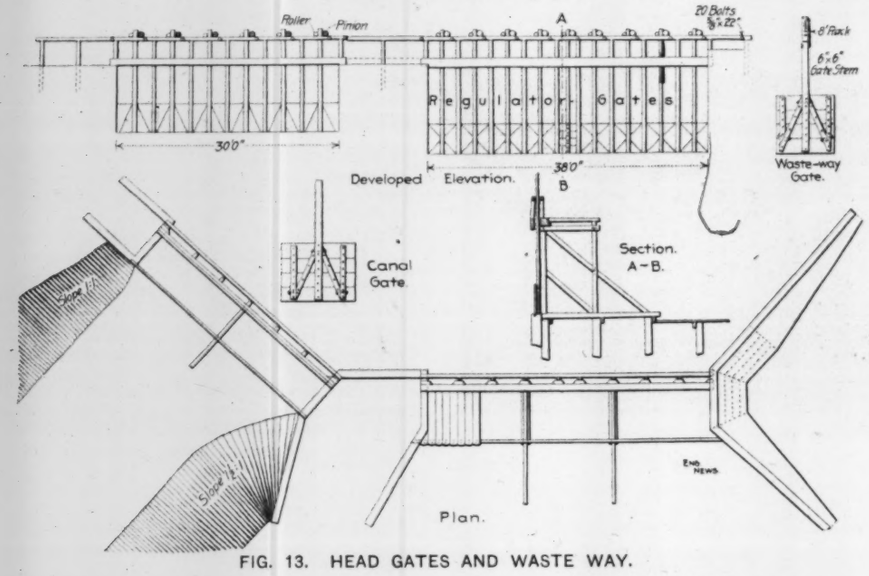

FIG. 13. HEAD GATES AND WASTE WAY.

ORGANIZING A CIVIL ENGINEERING CORPS.

By F. H. Newell,* M. Am. Soc. C. E.

At the present time there is a somewhat increased demand for young engineers, especially those of good experience. This arises from the fact that practically three new engineering corps of considerable magnitude are being organized: the New York Barge Canal Survey, the engineering force for work on the Panama Canal, and the U. S. Reclamation Service, for the examination and construction of national irrigation works.

The Reclamation Service is now fairly well outlined, and consists of about 200 men, who are designated as Engineers, Assistant Engineers and Engineering Aids. These have all been selected by competitive civil service examination, and are in line of advancement in engineering and related work. Besides these are other men employed in the field, temporarily, or in various capacities, but who are not considered as permanent members of the engineering force.

The bringing together of this body of men, and the experience had in employing a considerable number of engineers, especially young men, has afforded some interesting facts, and has given data in regard to salaries and opportunities for employment.

ENGINEERS' SALARIES.

The keen competition for these places gives an interesting sidelight on the compensation received by engineers. When it is considered that a large amount of money and time is invested by the engineer in preparation for his profession, the compensation sought is apparently small. The mechanic or day laborer is frequently paid more than the college graduate engaged as engineering aid on the same work. Salary paid is no criterion of ability, and a careful examination of many hundreds of papers filed by engineers, with statements as to the minimum salary which they would accept, shows that some of the best engineers of the country are receiving relatively small pay. There are apparently two classes of men in engineering, as in other professions, namely, the commercial and the professional class. The commercial engineers, through instinct or training, are able to obtain large salaries or fees, and to gain a reputation which is of immediate financial value to them. In contrast with these are men who apparently have accomplished as much, or better work, but who have absolutely lacked the faculty or opportunity to make their work and their abilities known to the public. These men are willing, or are compelled by circumstances, to accept a compensation which is relatively small, and out of all proportion to the value of the services given.

In the organization of the Reclamation Service the attempt is made to give a fair compensation; one which is reasonable and just, and which at the same time is worthy of the work in hand. The problems are extremely difficult and varied in character, ranging from earthwork construction through masonry and concrete, the planning and building of power plants, pumps, and other forms of hydraulic installation. A great variety of engineering experience must be had on the part of the different individuals or experts. Moreover, the work is widely scattered over the western part of the United States, and at localities relatively remote and inaccessible. Hence a high degree of business ability and executive skill must be displayed in getting results accomplished; and throughout all, loyalty and integrity in handling Government affairs.

POLITICAL PRESSURE.

In organizing any engineering corps under governmental auspices, whether city, state or national, the factor of political pressure must always be considered and wisely met. The Reclamation Service has been unusually fortunate in being relieved from all pressure of this kind, due to the fact that from the outset strict adherence to civil service requirements was insisted upon. One of the provisions of the civil service law enacted by Congress is that the endorsement of any Member of Congress or Senator shall not be considered by the appointing officer, excepting so far as this relates to residence. It thus results that even though an applicant should file letters from a Member of Congress, these are promptly returned and cannot become a part of the record.

As might be expected, hundreds, or perhaps thousands of applications have been made, directly or indirectly, through Members of Congress. Invariably the reply has been to refer the applicant to the Civil Service Commission for full information, with advice to take the next examination and thus seek a place on the eligible list. The men who are really competent seldom fail to follow this advice; but the men who are doubtful of their ability, and who therefore seek political influence are not willing to submit to the ordeal of an examination. The engineers thus come into the organization wholly free from any taint of preference, and understand that they have been selected wholly with reference to merit, and without regard to political, social, or religious bias. They also have clearly in mind the fact that any attempt to bring pressure to bear for preference in the work will be considered as a confession of weakness, or as an act of insubordination; and it is also quite well understood that any man who attempts to secure by indirection any advantage will be considered for reprimand, or ultimate dismissal at the first convenient opportunity.

Care is taken not to offensively state these conditions, but to have it understood that any violation of official courtesies and regulations in such matters will ultimately be to the disadvantage of the man concerned. It is intended at all times to maintain a healthy atmosphere of friendly competition among the men, and at the same time enforce absolute fairness and impartiality as regards the judgment of ability displayed.

CONTINUITY OF EMPLOYMENT.

In any discussion of engineers' salaries a large factor to be taken into consideration is the probability of continuous employment and gradual advancement. This is a very important matter, and in comparing the salaries of the Reclamation Service it must be borne in mind that there is probability of work continuing during the lifetime of the individual, or at least during his period of efficiency. There is also reasonable hope of advancement to the higher positions where judgment and engineering advice is expected, rather than bodily activity and rapid performance of mechanical work.

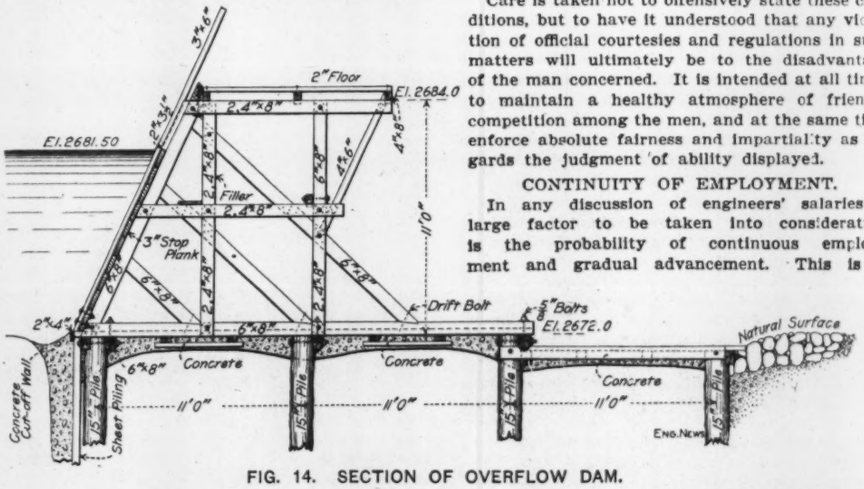

FIG. 14. SECTION OF OVERFLOW DAM.

*Chief Engineer Reclamation Service, U. S. Geological Survey, Washington, D. C.

These factors have great importance, as is shown by the fact that men in private employment have been and are willing to accept salaries averaging 50 to 75% of the annual income from the ordinary sources. It is with many persons a source of pride to be connected with a large organization; and a reasonable security against diminution of income during hard times compensates for a smaller average earning.

The Reclamation Service and its work grows out of the law of June 17, 1902, setting aside the proceeds from the disposal of public lands for the construction of irrigation works. At the time the reclamation law went into effect there already existed, as one of the branches of the U. S. Geological Survey, a small body of engineers who had been devoting their time to the study of the water resources of the country and the extent to which the arid lands might be reclaimed.

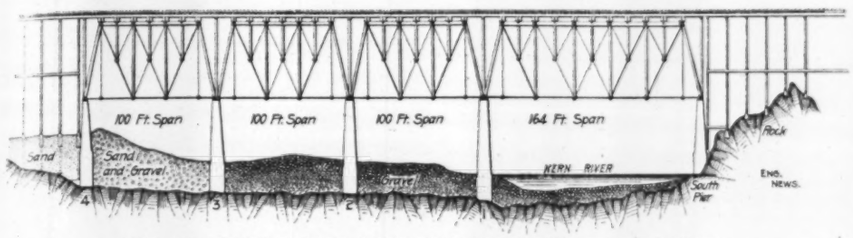

FIG. 15. TRUSS BRIDGE CARRYING FLUME ACROSS KERN RIVER.

CIVIL SERVICE MEN.

Beginning with these as a nucleus there have been added from time to time additional men, as needed in the execution of various surveys and projects leading up to the construction of large works. The facilities offered by the Civil Service Commission were utilized, and certificates obtained from various lists of eligibles. By examining the papers of the eligibles and consulting references given it was possible to offer each man a minimum salary which his experience and general qualifications seemed to justify. That is to say, taking the list as submitted, the first man was considered, and he was offered what seemed to be reasonable compensation. If he accepted he was taken on probation for six months and his salary determined by the character of his work. It has been assumed that, irrespective of a man's training and experience, he should demonstrate what he could do under existing conditions before his relative standing would be settled. It has been found, for example, that men who surpassed in certain work in the East have not been so successful as anticipated in other work in the arid region; and on the other hand some men who would probably not rank high in the East have been very valuable in organizing and conducting field work in the arid region.

In the gradual development of the Reclamation Service it has been found desirable to have two sets of examinations, repeated in the spring and in the fall. These two sets of examinations are intended to cover two classes of men. First, the engineering aid examination is for the young college graduate or men fresh from school, with a full knowledge of mathematics and the theory of engineering, but without much practical experience. For him a somewhat severe scholarly test has been applied, in order to select young men well qualified for these lower positions, and who, as experience is gained, can be advanced to the higher positions.

The second form of examination is designed for more experienced men, who have presumably forgotten much of their scholastic studies or become rusty in mathematics, but who have had a good experience in various lines of investigation and construction. In these examinations experience counts very largely, while scholarly attainments are rated relatively less.

The eligibles resulting from these two lists are treated alike. That is, each man is considered on the basis of what he can probably do, is offered a minimum compensation, and with the understanding that if he demonstrates his ability he will be advanced accordingly. Some men have thus gone ahead rapidly; others have been dropped at the end of the six months' probation, or before; and others have remained and gone ahead slowly.

AGES AND SALARIES.

A somewhat interesting comparison has been made of the results obtained of the selection of upwards of 200 men under this scheme. It appears that 71 aids receiving from $60 to $75 per month up to $1,000 per annum, the ages range from 21 to 36 years, or an average of 25.41 years. The next higher classes, known as assistant engineers, receive salaries of $1,200, $1,400 and $1,600 per annum. Of 81 persons considered the ages ranged from 24 to 50, which gives an average of 32.12. Of the engineer grade, each receiving from $1,800 per annum upwards, there were 43 considered, and the ages ranged from 28 to 54, an average of 38.14.

A more detailed comparison of individuals by salary and age is given in the following table. The classes are those designated by the civil service law. Class A is the lowest, of which none are considered. The men in class B are paid in round numbers, $60 per month; Class D, $75 per month; Class E, $1,000 per annum. Class 1 includes men at $1,200 per annum; Class 2, $1,400; Class 3, $1,600, and so on, as shown by the figures in the second column.

Grade.	Annual salary.	No. in grade.	Ages, years: Maximum.	Minimum.	Average.
Engineers:					
Class 6.	$2,500 +	13	63	40	47.61
Class 5.	2,000	23	46	30	38.35
Class 4.	1,800	21	46	28	34.48
Assistant Engineers:					
Class 3.	1,600	21	49	24	34.48
Class 2.	1,400	33	43	25	31.30
Class 1.	1,200	27	44	25	30.67
Aids:					
Class E.	1,000	31	36	22	26.29
Class D.	900	26	30	21	24.88
Class B.	720	14	28	21	24.61

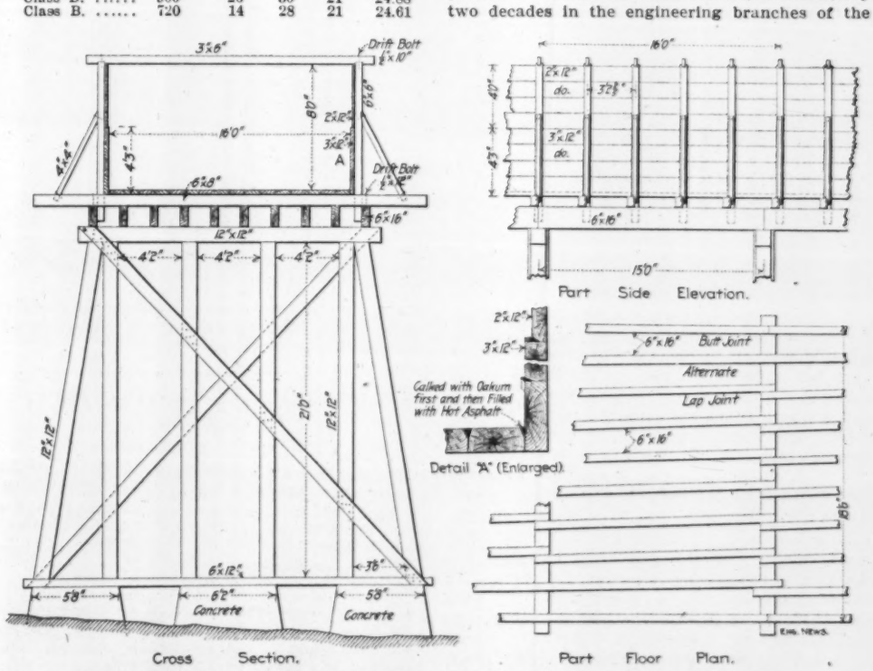

FIG. 16. SECTION OF HIGH TRESTLE ON APPROACH TO KERN RIVER BRIDGE.

In the designation of engineers and assistants the scheme adapted has been to classify as engineering aids all of the young men occupying positions below $1,200 a year. The service performed by most of these men is comparable to rodman, recorder or leveller in the usual engineering party, or sub-inspector on public works. Most of the young men are graduates of technical schools, and in time are expected to pass through the various classes up to the highest.

On reaching an annual salary of $1,200, the men are designated as assistant engineers, and perform duties equivalent to levelman, transitman, and chiefs of small parties.

On reaching a salary of $1,800, a man is designated as engineer, and is assumed to have the necessary qualifications and experience to carry on independent work of surveying, designing or construction, without continual oversight, but with general orders from a distant chief, and occasional advice from consulting engineers. He usually has under his charge several parties more or less scattered, and should have judgment and ability to handle these economically and effectively. From here on upwards his duties become those of an executive, or of a consulting or constructing engineer, according to circumstances or tastes.

PROMOTIONS.

Promotions are based wholly upon efficiency and upon work performed. Age or length of service is not considered, except as an incident of ability to accomplish results, or as a determining factor between two men of about equal strength. In the spring and fall of each year all engineers are called upon for a statement concerning the men under their charge, or observation, and recommendations are received for promotion. These are referred to a Board of Engineers, who have had the widest experience; and this board, taking for example all of the names of the $1,200 class, and the statements concerning them, recommend for promotion certain individuals. Some of these may have been promoted six months before; others may have been passed over for several years in succession.

Consideration is had not only of the work which a man has performed, but his probable ability to succeed in a higher position. It is hoped in this way, by picking over the men, to push forward those who have showed marked ability, and to stimulate others, who cannot fail to see that promotion must be earned by making greater efforts.

It has been found as a result of two years' experience in the Reclamation Service, and of nearly two decades in the engineering branches of the Geological Survey, that for the average man promotion takes place about once in two years, each step being about $200 advance, or at the rate of $100 per year. Upon this basis a table has been prepared, showing the age, designation, salary, and percentage of annual increase from lower to

higher positions, on the assumption that increase is made every second year by one step or class. As a matter of fact some men go ahead more rapidly than others, and some do not advance at all; and in the higher classes, the positions being relatively fewer, the opportunities for advancement are less.

The percentage of annual increase has been figured in round numbers, and shows that while advance in lower grades is relatively large, in the higher it rapidly drops to 4 or 5%. This table is given merely as a matter of interest, to show what might take place under this system if rigidly carried out, and to indicate the apparent relation which exists between age periods and salary received. The table given before, based on actual conditions should be consulted.

Assumed age.	Actual average age.	Designation.	Salary per annum.	Per cent. of annual increase.
22	24.61	Engineering aid	$720	14
24	24.88	" "	900	6
26	26.29	" "	1,000	10
28	30.67	Assistant engineer....	1,200	8
30	31.30	" "	1,400	7
32	34.48	" "	1,600	6
34	34.48	Engineer	1,800	5 +
36	38.35	"	2,000	5
38	47.61	"	2,200	4 +
40	.....	"	2,400	4 +
42	.....	"	2,700	6 +
44	.....	"	3,000	6 —
46	.....	"	3,300	5
48	.....	"	3,600	5 —
50	.....	"	4,000	2½

A PLANT FOR THE MANUFACTURE OF CONCRETE BLOCKS FOR BUILDINGS.

The construction of concrete blocks for building purposes is developing into a special industry and in plants of this kind it is important to devise methods ensuring facility and economy in handling the materials. The Pressed Stone Mfg. Co., of St. Paul, Minn., has a plant for manufacturing the Miracle patent hollow-concrete blocks, and the entire plant, as well as the style of press used, was designed by the Miracle Pressed Stone Co., 602 Northwestern Building, Minneapolis.

The plant has the Mississippi River on one side, from which is taken the sand used in the concrete; and on the other side is a shipping track of the Chicago, St. Paul, Minneapolis & Omaha Ry. The building is 24 × 48 ft., and includes a two-story section 24 ft. square and 34 ft. high, in which is contained all the machinery. The one-story portion is used for the storage of the green blocks and is supplemented by a shed 72 ft. long. After the blocks are sufficiently dry to handle, which is about 48 hours from the time they leave the press, they are piled in the yard. The arrangement of the plant is clearly shown in Fig. 1.

The sand pumped from the river is delivered into the boot of a bucket elevator, about 6 ft. below the first floor. This elevator discharges at the top of the building into a screen which separates the sand and gravel, and delivers them into two storage bins over the concrete mixer on the second floor. The cement is stored in a similar bin, and the bins feed into a chute fitted with a measuring device. This consists of a cast-iron cylinder with a slot 5 ins. wide extending its entire length, the ends of the cylinder being closed. It is operated by a crank handle on a rod which passes through the center of the cylinder. A Broughton concrete mixer is used, and the proportions are usually 1 to 5.

After a thorough mixing the concrete is dumped from the mixer into another hopper located behind the press, as shown in Fig. 3, and from here it is again measured out by a device similar to that above mentioned, into a truck carrying a box of sufficient capacity for material for one block. The truck runs on a narrow gage track and upon being filled is run forward a distance of about 5 ft., bringing the box which it carries directly over the mold of the press. The box has a false or movable bottom, operated by a lever, by means of which the material is delivered to the mold.

The press is now run down, compressing the block to the proper thickness, and at this point the mold is opened, as in Fig. 3. Two arms attached to the follower of the press are thrown down to hang in a perpendicular position, and engage with a plate on which the block is made. After this operation, the press is started on its upward travel, carrying the block with it to clear the top of the cores, which can be seen in the cuts. The block is then placed on a rack, leaving the press in readiness for another block, and the racks are carried away on trucks to the storage room.

The power to run the plant is furnished by a 7½-HP. 220-volt, 60-cycle Westinghouse induction motor, running at a speed of 1,120 revolutions, and driving the line shaft at 300 revolutions per minute. From the line shaft, belts are run to an automatic stop and reversing gear, similar to those used in elevator work, the gear being connected through another set of belts and a short countershaft to the press, which is of the toggle pattern, as shown, and gives a pressure of 120 tons. The press is automatically stopped at the extreme limits of its travel (about 13 ins.), compressing the block to an even thickness of 7¾ ins. and of a uniform density. The press is for the manufacture of hollow concrete building blocks under the patents of Orville U. Miracle and W. L. Dow. These blocks have double rows of air spaces, staggered in position. It is claimed that with this machine three men and two boys can easily turn out and care for 300 blocks per day of ten hours. At this rate, the cost of labor would be from 2½ to 3 cts. per block.

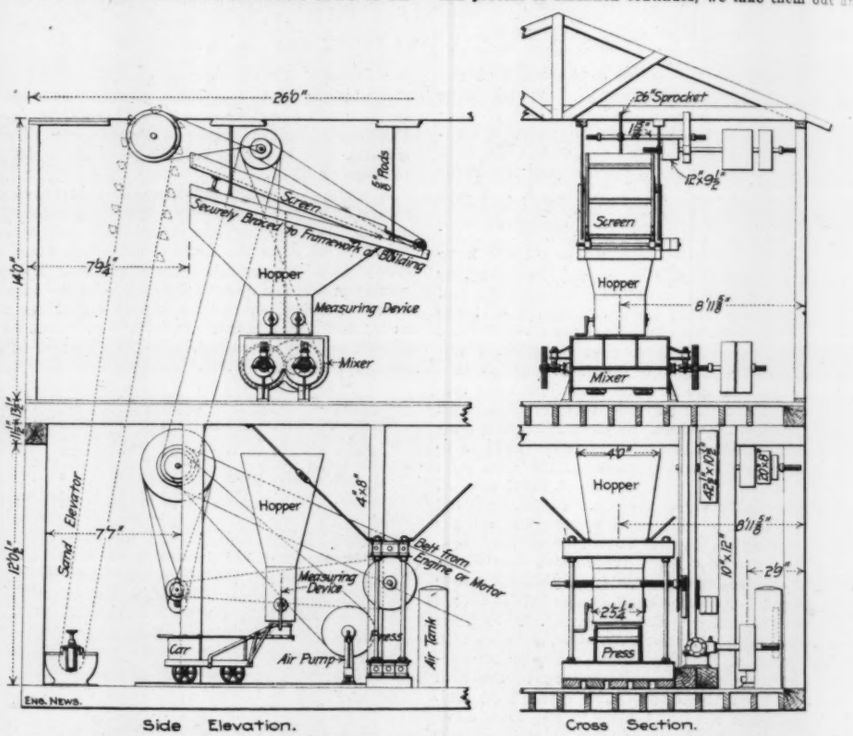

FIG. 1. GENERAL ELEVATION AND CROSS-SECTION OF CONCRETE BLOCK-MAKING PLANT AT WORKS OF MIRACLE PRESSED STONE CO., ST. PAUL, MINN.

FOAMING WATERS AND SCALING WATERS FOR LOCOMOTIVE BOILERS.*

By M. E. Wells.†

The impurities in average boiler water are divided into two general classes—incrusting solids and alkaline salts. Under the head of incrusting, or scale-forming solids, are listed the carbonates and sulphates of lime and magnesium as follows:

Calcium carbonate (lime)	$CaCo_3$
Calcium sulphate (gypsum).....	$CaSO_4$
Magnesium carbonate	$MgCo_3$
Magnesium sulphate	$MgSO_4$

These are all soluble when they enter the boiler, but are precipitated by heat. They are the only impurities really considered, in a general way, by water softening machines and methods.

Under the head of alkaline salts are to be listed the carbonates and sulphates of soda. Most waters contain a small per cent. of chloride of soda (common salt); and while it is not an alkali, it being a salt of soda, it is added to the list of alkalis. So the list of alkali is as follows:

Carbonate of soda.....	Na_2CO_3
Sulphate of soda	Na_2SO_4
Chloride of soda	NaCl

These are always soluble before as well as after entering the boiler.

One reads in the books about magnesium chloride and a few other things as being very corrosive, and that waters containing it should be avoided. This is true, but when one considers that on all lines of the Burlington Railroad west of the Missouri River there are but [illegible] water stations, out of about 200, that show magnesium chloride—and these show but about two grains to the gallon—we in this section of the country have but little to fear from the action of this chemical on our boilers. People should stop imagining that some dark, deep and mysterious thing is corroding their boilers, and realize that it is only simple oxidation—just what takes place when iron lies out in the weather and rusts.

The worst corrosion of flues I have ever seen had taken place while they were lying in a pile out in the weather. When flues corrode in this manner, we do not say very much about it; but when we put them into a boiler, and this process of oxidation continues, we take them out and say "bad water." As long as water is used in iron boilers there will be oxidation or rusting; and perfectly pure water is the most corrosive that can be put into a boiler. If any of you have ever tried using iron pipes for carrying condensed water, you have found them rusting out very rapidly.

I was much interested recently in an immense storage battery used in connection with an electric railway. They must have the purest of condensed water for the battery, and the tank that held this water, and all the connecting pipes were of copper. An iron tank and pipes would not have lasted long, and neither would the impurities resulting from corrosion work well in the battery. Here we are confronted with the fact that nature has, in a measure, provided incrusting matter in water, that the inside of the sheets of boilers may be coated with a layer of it, and thus be protected from this oxidation. Now, the more uniformly boilers are cooled, the less this scale is disturbed, and the more protection it is to the iron.

One always finds marked corrosion on the external bends of flanges in flue sheets and fire boxes. The enamel of the iron was broken in the flanging, and put the iron in a condition to be easily attacked by the corrosive action of the oxygen and carbon dioxide in the water. If a boiler is not cooled uniformly, there is always more or less of a bending action going on at these points, keeping the protective scale broken off, and opening the corrosive spots already started to more continued corrosion. We are positive about this bending or disturbing action of the iron, because we have seen where crowfoot braces have

*Condensed from a paper in "Nebraska Engineering."

†Chief Boiler Inspector, Burlington & Missouri River R. R.

be applied to the flat surfaces of sheets, and the enamel of the iron has not been disturbed. Yet I have seen almost as bad corrosion take place around the feet of these cross foot braces as I have seen in any bent flange;—showing that these braces have pulled and pushed and put sufficient bending strain in the iron around the feet, to keep the scale off and thus allow corrosion.

It is because the carbonates and sulphates of lime and magnesium make water hard, and the removing of them makes it soft, that the softening or purifying plants, are so named. There is, however, one feature of this that is not so well understood; and that is, that soft water may also contain large quantities of alkali that will make it very undesirable for boiler water. The boiler or tank water on the Burlington Railroad between Newcastle and Sheridan, Wyo., is the worst alkali district on this road, and it is the most difficult division to operate, on account of the boilers foaming from the excess of alkali. The waters are very soft; in fact there is more soft water between Sheridan and Newcastle than on any other division of the Burlington. Yet, it is the hardest division to do business over; and boilers are washed out oftener than on any other division of the road.

$$CaCO_3 + CO_2 + 2NaOH = \underbrace{CaCO_3}_{\text{Insoluble}} + \underbrace{Na_2CO_3}_{\text{Soluble}} + H_2O.$$

Or, for the removal of magnesium carbonate (MgCO), the following is the reaction:

$$MgCO_3 + CO_2 + 2NaOH = \underbrace{MgCO_3}_{\text{Insoluble}} + \underbrace{Na_2CO_3}_{\text{Soluble}} + H_2O.$$

By the use of caustic soda one of the products left in the water is carbonate of soda (alkali). On account of its foaming properties, this is bad; and therefore caustic soda should not be used to take out the carbonates of lime and magnesium. Lime-water is better since it does not leave or increase the alkali in the treated water.

But to remove calcium and magnesium sulphate from water is a very different thing; and the result is also very different. The chemical that is used by nearly all treating plants to remove these, is soda ash—carbonate of soda (Na_2CO_3). The chemical reactions are as follows, for removing calcium sulphate ($CaSO_4$):

$$CaSO_4 + Na_2CO_3 = \underbrace{CaCO_3}_{\text{Insoluble}} + \underbrace{Na_2SO_4}_{\text{Soluble}}.$$

You will note that the products of the chemical reaction are insoluble carbonate of calcium, and soluble sulphate of soda;—this last, of course being left in the water. So that this method is simply a question of trading the soda for the calcium; or, in other words, changing an incrusting water to an alkali or foaming water. In order to shew the increase in alkali, I quote the results of four water-treating plants in use on the C. & N. W. Railway, between Boone and Council Bluffs, and taken from the February, 1903, report of the Western Railway Club:

Items.	Before, grs. per gal.	After, grs. per gal.
Council Bluffs, Ia. (wells, 70 ft. deep).		
Total solid matter	53.67	31.65
Incrusting solids	47.48	3.84
Non-incrusting solids	6.79	27.59
Lbs. scale-forming matter in 1,000 gallons	6.69	0.51
Denison, Ia., (well, 25 ft. deep).		
Total solid matter	24.19	16.50
Incrusting solids	23.04	5.13
Non-incrusting solids	1.15	11.67
Lbs. scale-forming matter in 1,000 gallons	3.29	0.73
Dunlap, Ia. (well, 28 ft. deep).		
Total solid matter	40.42	23.61
Incrusting solids	35.37	6.90
Non-incrusting solids	5.05	16.41
Lbs. scale-forming matter in 1,000 gallons	5.05	0.98
West Side, Ia. (well, 28 ft. deep).		
Total solid matter	51.63	28.18
Incrusting solids	43.85	4.75
Non-incrusting solids	7.48	23.43
Lbs. scale-forming matter in 1,000 gallons	6.36	0.68

Note the increase in non-incrusting solids, which means alkali.

There is no known method of treating alkali water to remove the alkali, except by evaporation and condensation. In fact, the present method of removing calcium sulphate by the use of soda ash, only increases the alkali. The only salvation we have in running trains between Sheridan and Newcastle is because we have water at Arvada and Moorcroft that is incrusting rather than alkali. If we were to put up a modern purifying plant at these places to take out the calcium sulphate by means of adding carbonate of soda (soda ash), it would be practically impossible to get trains over this division without stopping to wash out at Gillette; and then we would be leaving Gillette with water in the boiler running about 25 grains of alkali to the gallon. With this kind of water, it would only be necessary to use eight boilers full, when you would have reached the foaming point again.

FIG. 2. VIEW ON DELIVERY SIDE OF CONCRETE BLOCK PRESS.

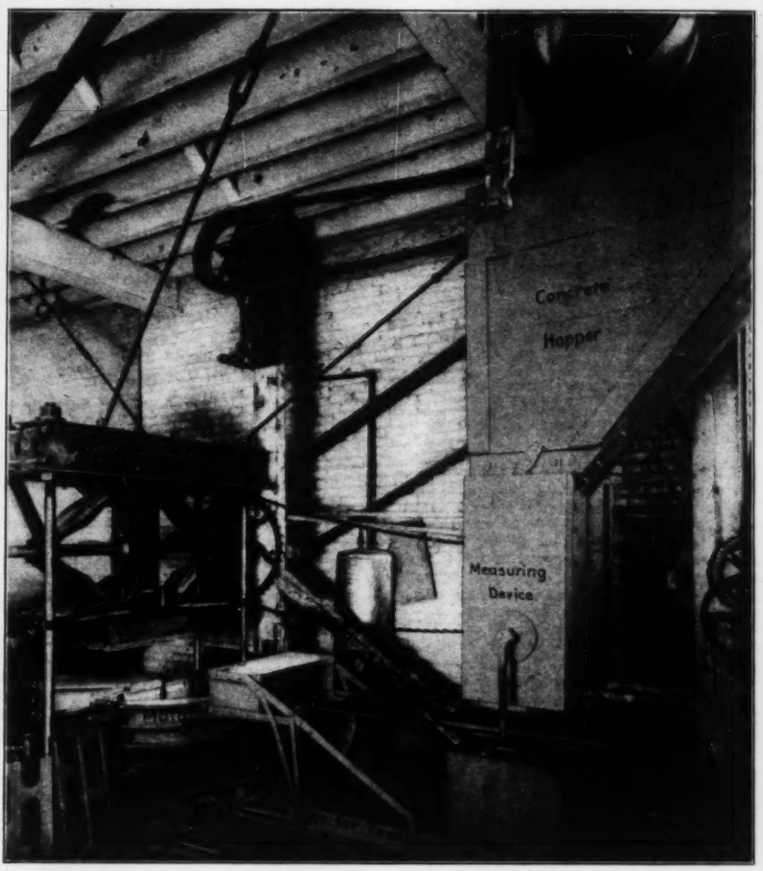

FIG. 3. VIEW SHOWING SYSTEM OF DELIVERING CONCRETE TO PRESS.

In order to get a clear idea of this water treatment problem we will first take up, somewhat in detail, what is done when waters are treated. Calcium and magnesium carbonates are held in solution in the water, on account of the presence of carbon dioxide (CO_2). What is necessary then, to precipitate the lime and magnesium is to take the carbon dioxide out of the water. This is done by adding lime water $Ca(OH)_2$. This, having a strong affinity for the CO_2 gas, soon takes it up, and the carbonates of lime and magnesium come down in the form of a white powder. The lime-water that is put in, forms with the gas it takes up, more of the carbonate of lime, which is also precipitated; the water then drawn off is practically free from these carbonates. If, then, the proper amount of lime-water is added and the proper settlement allowed, the carbonates of lime and magnesium are removed, and nothing is left in the water in the place of it. The chemical reaction is as follows:

$$CaCO_3 + CO_2 + Ca(OH)_2 = 2CaCO_3 + H_2O.$$

And when magnesium is removed, the reaction is

$$MgCO_3 + CO_2 + Ca(OH)_2 = MgCO_3 + CaCO_3 + H_2O.$$

Caustic soda (NaOH) can also be used to absorb the carbon dioxide (CO_2) and thus cause the precipitation of the carbonates of lime and magnesium, as per the following reaction:

The railroad companies that are going so heavily into water purifying plants, are overlooking the fact that if they are removing calcium sulphate, they are only trading an incrusting water for an alkali water. Better railroading can be done with an incrusting water than can be done with an alkali water. Mr. Stillman, Engineer of Tests of the Southern Pacific, agreed with me when I made this statement in the Pacific Coast Railway Club, last August in San Francisco. It is impracticable to take out calcium sulphate by means of carbonate of soda; and the more calcium sulphate you have, the more impracticable it is, because the more alkali is left in the water. Below is a comparison of Felix, Wyo., water, on the B. & M., and the water the C. & N. W. people have at Council Bluffs, Ia., after treatment:

	Felix, Wyo.	Council Bluffs, Ia.*
Silica	0.46	0.38
Al & FeO_4	....	.02
$CaCO_3$	2.68	2.26
$MgCO_3$	0.70	0.88
Incrusting solids	3.84	3.54
Na_2SO_4	1.64	26.32
NaCl	1.22	1.27
Na_2CO_3	26.35	....
Alkali	28.01	27.59

*After treatment.

So you see, the C. & N. W. people have spent a lot of money at Council Bluffs to get the same kind of water that we have at Felix, Wyo. And the fact is, we wish we didn't have the Felix water. If we had at Felix the water the C. & N. W. has at Council Bluffs before treatment, we would be able to do much better railroading between Sheridan and Newcastle. If boilers are properly cared for and cooled, the incrusting solids give very little trouble; and there is no more washing out in one case than in the other. They are washing out now on the C. & N. W. on account of alkali, just as we are doing on this division.

If, then, it is not practical to remove calcium sulphate in water treatment, is it practical to remove the carbonates by means of lime water, when they make so little trouble from scale, if boilers are carefully cooled. I quote from my paper on incrustation, read before the Pacific Coast Ry. Club in August, 1903:

It is our experience that by the careful cooling of our boilers to prevent inequalities of contraction, we builded better than we knew. By constantly watching the cooling and washing of the boilers, we discovered that the more carefully they were cooled the more white mud came down to be washed out. Being interested to know what this white mud was, we took some of it to the laboratory for analysis, with this result:

Sulphate of line ($CaSo_4$)	4.90
Carbonate of lime ($CaCO_3$)	32.02
Carbonate of magnesium ($MgCo_3$)	30.00
Silica	1.12
Water	31.90

You will notice that it is made up largely of the carbonates of lime and magnesium, with a little sulphate of lime and water of crystallization. After following this cooling and washing for some months, it was very apparent that the scale from boilers carefully cooled became less, and what there was of it was of a different texture from the boiler scale we had been accustomed to—averaging only about the thickness of an egg shell. We also discovered that when it got to this thickness it would detach itself and come down and wash out.

In a general way I would say for the average stationary boiler owner in Nebraska: "Don't buy boiler compounds." If you have calcium sulphate in your boiler water and it is low in alkali, buy and add enough soda ash to change it into the carbonate. Cool your boilers down by putting cold water in at a high point in the boiler, and letting the hot out at a low point, keeping the boiler full until cool. Or else if you have plenty of boilers let your boiler stand and cool itself before washing out.

A good non-incrustant is tannin extract, one form being Quebracho wood extract. This to be dissolved in water and fed into the boiler with the feed water. Keep enough in the boiler to show a very faint red tint in the water glass. The incrusting matter has a very strong affinity for and takes up this tannin out of the water. In doing this the incrusting matter is colored a reddish brown and its cementing action destroyed and it comes down, and can be washed or blown out. Old scale can be loosened, and new scale kept from forming by adding a gallon of headlight oil to a boiler every time it is washed out and before filling. You can loosen old scale and keep boilers in general good condition by heating them up about once a month with a very strong solution of soda ash in the water. Don't try to use steam from the boiler while doing this, for it will foam. Cool your boiler down properly, and let out water and wash after doing this.

Of course it is necessary to have extra boilers to do this, but all people using steam are coming to the opinion that to be short on boilers means boiler troubles because there is not usually the proper time to take the proper care. Some of the largest and best boiler plants are equipped with reserve boilers, and they find it pays in order that the proper care can be taken of them. If you can't take the proper care you must expect boiler troubles.

A NOVEL CONCRETE-STEEL BRIDGE ABUTMENT ON THE WABASH RAILROAD.

A retaining wall nearly 30 ft. high with a maximum thickness of face masonry of only 2 ft. 2½ ins. is well worthy of consideration. Such a wall is shown in Fig. 1, which is a photograph of the back of a bridge abutment on the Wabash Railroad at Monticello, Ill.

As shown in the cross-section, Fig. 2, the abutment consists of a footing, or floor, a face wall, and buttresses connecting the floor to the wall, the whole consisting of concrete in which are embedded Johnson corrugated steel bars. It is obvious that the earth filling between the buttresses will rest upon the floor, thus preventing an overturning that would otherwise surely occur were the weight of the face wall the only means of resisting the thrust. It will also be noted that the bridge seat is itself in part a floor of reinforced concrete resting upon the buttresses.

FIG. 1. VIEW OF BACK OF ABUTMENT FOR WABASH R. R. BRIDGE AT MONTICELLO, ILL.

Mr. W. S. Newhall is Chief Engineer, and Mr. A. O. Cunningham is Bridge Engineer of the Wabash Railroad.

We are indebted for our illustrations to a recently published catalogue issued by the St. Louis Expanded Metal Fireproofing Co., 606 Century Building, St. Louis, Mo.

SOME FORMULAS AND TABLES FOR BIN DESIGNING.

By R. W. Dull, M. E.*

The design of bins and hoppers for storing materials, such as coal, ashes, etc., is not based on so exact a theoretical foundation as is the design of bridges, for example. Moreover, in any specific case the peculiarities of the particular substance handled introduce large uncertainties as to the practical conditions. The problem is only little less difficult than that of designing retaining walls. The forces acting on the bin-walls depend upon the weight, angle of repose, condition of moisture, etc., of the material, most of which factors are variable. The design of bins must therefore be founded on average conditions and approximate assumptions as to how the material acts.

As an aid to the designer, the present article summarizes the principal formulas which are required by the designer of bins or hoppers, and in conjunction therewith gives some tables of pressure-constants for several cases of bins or hoppers, for four different materials: anthracite coal, bituminous coal, ashes, and sand. The formulas are founded on the theory given by Prof. Wm. Cain, whose work† the bin designer should be familiar with.

The assumptions made in the following article as regards weights, angles of repose, etc., are based mainly on the practice of the Link-Belt Machinery Co., of Chicago.

The following symbols are used in the formulas:

ϕ = angle of repose, measured from horizontal.
ϕ^1 = angle of friction between material and bin-wall = angle between direction of thrust and normal to plate surface.
P = total thrust against bin-wall plate for a section one foot thick.
N = normal component of P.
ϵ = slope of surface of material, measured from horizontal.
α = angle which bin-wall or bottom makes with vertical.
w = weight of material per cubic foot.
W = total weight of material in a section one foot thick.

The formulas below give the thrusts P and N for ten different cases occurring in bin and hopper work:

CASE 1.—Vertical wall. Surface level.

$$P = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{wh^2}{2\cos\phi^1}$$

$$N = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{wh^2}{2}$$

where

$$n = \sqrt{\frac{\sin(\phi+\phi^1)\sin\phi}{\cos\phi^1}}$$

If $\phi = \phi^1$, then $n = \sqrt{2}\sin\phi$, and

$$P = \frac{wh^2}{2}\cdot\frac{\cos\phi}{(1+\sqrt{2}\sin\phi)^2}$$

$$N = \frac{wh^2}{2}\cdot\frac{\cos^2\phi}{(1+\sqrt{2}\sin\phi)^2}$$

If $\phi^1 = 0$, which corresponds to a very smooth wall, then

$$P = N = \frac{wh^2}{2}\tan^2\left(45° - \frac{\phi}{2}\right)$$

Table of Constants for Steel-Plate Bins.—Case 1.

Material.....	ϕ	ϕ^1	w	P	N
Bituminous Coal.	35°	18°	50 lbs.	0.13h^2	5.88h^2
Anthracite Coal..	27°	16°	52	8.73h^2	8.38h^2
Sand.....	34°	18°	90	11.5h^2	10.93h^2
Ashes.....	40°	31°	40	4.02h^2	3.44h^2

N.B.—If the bin has concrete lining it is well to make $\phi^1 = \phi$.

CASE 2.—Vertical wall. Surcharged surface.

$$P = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2\cos\phi^1}\cdot h^2, \quad N = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2} h^2$$

where $n = \sqrt{\frac{\sin(\phi+\phi^1)\sin(\phi-\epsilon)}{\cos\phi^1\cos\epsilon}}$

If we assume $\epsilon = \phi$

$$P = \frac{\cos^2\phi}{\cos\phi^1}\cdot\frac{w}{2}h^2, \quad N = \cos^2\phi\,\frac{w}{2}h^2$$

If we assume $\epsilon = \phi$ and $\phi = \phi^1$,

$$P = \frac{\cos\phi}{2}wh^2$$

If ϕ^1 is assumed equal to ϵ,

$$P = \cos\epsilon\,\frac{\cos\epsilon - \sqrt{\cos^2\epsilon - \cos^2\phi}}{\cos\epsilon + \sqrt{\cos^2\epsilon - \cos^2\phi}}\cdot\frac{w}{2}h^2$$

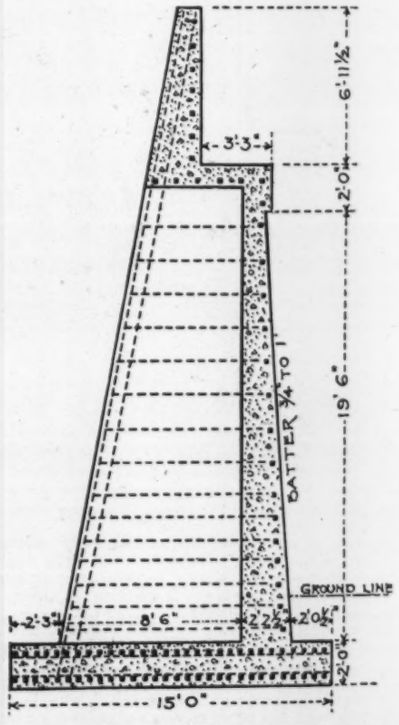

Fig. 2. Vertical Section of Abutment for Wabash R. R. Bridge at Monticello, Ill.

The direction of P in this case is parallel to the surface.

Table of Constants for Steel-Plate Bins.—Case 2.

Material.....	ϕ	ϕ^1	w	P	N
Bituminous Coal.	35°	18°	50 lbs.	17.65h^2	16.75h^2
Anthracite Coal..	27°	16°	52	21.45h^2	20.6h^2
Sand.....	34°	18°	90	32.5h^2	30.9h^2
Ashes.....	40°	31°	40	13.7h^2	11.73h^2

N. B.—The above assumptions are taken as maximum conditions, with the angle of surcharge ϵ in each case equal to the angle of repose ϕ, and the horizontal area of the bin unlimited in extent.

*Estimator, Link-Belt Machinery Co., Chicago, Ill.
†The Practical Designing of Retaining Walls, Van Nostrand & Co., New York.

CASE 3.—Vertical wall, surface sloping down.

$$P = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2\cos\phi^1} h^2, \quad N = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2} h^2$$

where

$$n = \sqrt{\frac{\sin(\delta+\phi^1)\sin(\delta+\epsilon)}{\cos\phi^1\cos\epsilon}}$$

Assuming $\phi' = 0$, which we have when there is no friction between the vertical surfaces and used when the surfaces settle together:

$$P = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2} h^2$$

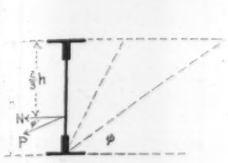

Fig. 1.

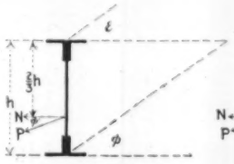

Fig. 2.

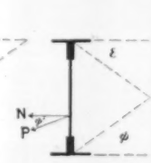

Fig. 3.

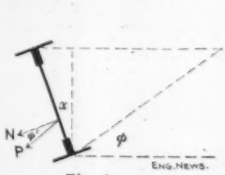

Fig. 4.

DIAGRAMS FOR CASES 1 TO 4.

where

$$n = \sqrt{\frac{\sin\phi\sin(\delta+\epsilon)}{\cos\epsilon}}$$

Table of Constants for Steel-Plate Bins.—Case 3.

Material.....	ϕ	ϕ^1	w	P	N
Bituminous Coal.	35°	18°	5 lbs.	$4.4\,h^2$	$4.27h^2$
Anthracite Coal..	27°	16°	52	$6.61h^2$	$6.3\ h^2$
Sand.....	34°	18°	90	$8.69h^2$	$6.34h^2$
Ashes.....	40°	31°	40	$2.85h^2$	$2.5\,h^2$

N. B.—In calculating the above constants, the angle of slope ϵ was taken equal to the angle of repose ϕ.

CASE 4.—Wall leaning outward, but within limiting plane. Surface level.

$$P = \left(\frac{\cos(\delta-a)}{(n+1)\cos a}\right)^2 \frac{w}{2\cos(\delta^1+a)} h^2;$$

$$N = \left(\frac{\cos(\delta-a)}{(n+1)\cos a}\right)^2 \frac{w\cos\phi^1}{2\cos(\phi^1+a)} h^2$$

where

$$n = \sqrt{\frac{\sin(\delta+\phi^1)\sin\phi}{\cos\phi^1\cos a}}$$

CASE 5.—Wall leaning outward but within limiting plane. Surcharged surface.

$$P = \left(\frac{\cos(\delta-a)}{(n+1)\cos a}\right)^2 \frac{w}{2\cos(\delta^1+a)} h^2$$

$$N = \left(\frac{\cos(\delta-a)}{(n+1)\cos a}\right)^2 \frac{w\cos\phi^1}{2\cos(\phi^1+a)} h^2$$

where

$$n = \sqrt{\frac{\sin(\delta+\phi^1)\sin(\phi-\epsilon)}{\cos(\phi^1+a)\cos(a-\epsilon)}}$$

CASE 6.—Wall sloping outward beyond limiting plane. Level surface.

$$P = \tan^2\left(45° - \frac{\phi}{2}\right)\frac{w}{2}h^2$$

$$W = \text{weight of } \triangle ABC = \frac{w\tan a}{2}h^2$$

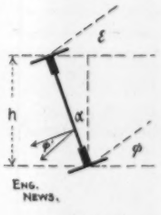

Fig. 5.

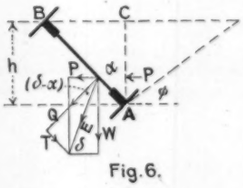

Fig. 6.

$$E = \sqrt{W^2 + P^2}$$

$$= \frac{w}{2}h^2\sqrt{\tan^2 a + \tan^4\left(45° - \frac{\phi}{2}\right)}$$

$$\tan\delta = \frac{\tan a}{\left(\tan^2(45° - \frac{\phi}{2})\right)}$$

$$Q = E\cos(\delta - a).$$

$$T = E\sin(\delta - a)$$

CASE 7.—Wall sloping outward beyond limiting plane. Surcharged surface.

$$P = \cos\epsilon\,\frac{\cos\epsilon - \sqrt{\cos^2\epsilon - \cos^2\phi}}{\cos\epsilon + \sqrt{\cos^2\epsilon - \cos^2\phi}}\,\frac{w}{2}h^2,$$

Direction of P is parallel to surface. See case 2.

$$W = \frac{w\sin a\cos(\epsilon - a)}{2\cos^2 a\cos\epsilon}h^2$$

$$E = \sqrt{P^2 + W^2 + 2PW\sin\epsilon}$$

If $\epsilon = \phi$ or the surface rests at the angle of repose

$$E = \frac{w\cos(\phi - a)}{2\cos^2 a\cos\phi}h^2$$

$$\sqrt{\sin^2 a + \cos^2(\delta - a) + 2\sin a\sin\phi\cos(\phi - a)}$$

and

$$\tan\delta = \frac{\sin a + \sin\phi\cos(\phi - a)}{\cos\phi\cos(\phi - a)}, \quad Q = E\cos(\delta - a),$$

$$T = E\sin(\delta - a).$$

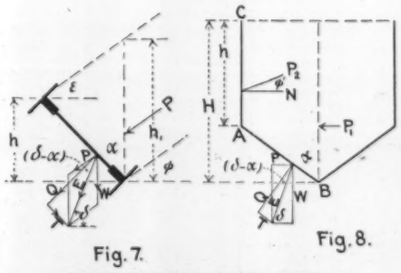

Fig. 7.

Fig. 8.

CASE 8.—Bin bottom. Surface level, sides of bin vertical.

$$P = \tan^2\left(45° - \frac{\phi}{2}\right)\frac{w}{2}(H^2 - h^1)$$

$$W = \frac{w\tan a}{2}(H^2 - h^1) - P_2\sin\phi^1$$

where $P_2 = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2\cos\phi^1}h^2$; $n = \sqrt{\frac{\sin(\delta+\phi^1)\sin\phi}{\cos\phi^1}}$

$$E = \sqrt{P^2 + W^2}$$

$$= \frac{w}{2}(H^2 - h^1)$$

$$\sqrt{\tan^2 a - \frac{4P_2\sin\phi^1[w\tan a(H^2 - h^2) - P^2\sin\phi^1]}{w^2(H^2 - h^2}} + \tan^4\left(45° - \frac{\phi}{2}\right)$$

$$Q = E\cos(\delta - a); \quad T = E\sin(\delta - a)$$

$$\tan\delta = \frac{\tan a - \frac{2P_2\sin\phi^1}{w(H^2 - h^1)}}{\tan^2\left(45° - \frac{\phi}{2}\right)}$$

Note.—The quantity $P_2\sin\phi^1$ is the friction on the vertical side and reduces the weight of mass on bottom AB. For pressure on AC proceed as in Case 1.

CASE 9.—Bin bottom. Surcharged surface. Sides of bin vertical.

$$P = \cos\epsilon\,\frac{\cos\epsilon - \sqrt{\cos^2\epsilon - \cos^2\phi}}{\cos\epsilon + \sqrt{\cos^2\epsilon - \cos^2\phi}}\,\frac{w}{2}(h^2 - h^2)$$

$$W = \frac{\sin a\cos(\epsilon - a)}{\cos^2 a\cos\epsilon}\,\frac{w}{2}(H - h)^2 + wh(H - h)\tan a - P_2\sin\phi^1$$

$$P_2 = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2\cos\phi^1}h^2$$

where $n = \sqrt{\frac{\sin(\delta+\phi^1)\sin(\delta-\epsilon)}{\cos\phi^1\cos\epsilon}}$

$$E = \sqrt{P^2 + W^2 + PW\sin\epsilon}$$

If $\epsilon = \phi$ = angle of repose

$$P = \frac{\cos\phi\,\omega}{2}(H^2 - h^2)$$

$$\tan\delta = \frac{W}{P\cos\epsilon} + \tan\epsilon$$

$$Q = E\cos(\delta - a), \quad T = E\sin(\delta - a)$$

CASE 10.—Hopper bottom. Surface heaped. Pressure on AB.

$$P = \left(\frac{\cos\phi}{n+1}\right)^2 \frac{w}{2}(h_1^2 - h^2)$$

where

$$n = \sqrt{\frac{\sin\phi\sin(\phi+\epsilon)}{\cos\epsilon}}$$

$$W = \frac{\sin a\cos(\epsilon - a)}{\cos^2 a\cos\epsilon}\,\frac{w}{2}(H - h)^2 + wh(H - h)\tan a - P_2\sin\phi^1$$

The expression for P_2 would be very complicated and tedious to solve for different widths, depths, etc., and it is therefore recommended that P_2 be found by graphical methods.

Table of Constants for Steel Plate Bins.—Case 7.

Material.	ϕ	ϵ	a	w	E	Q	T	δ
Bituminous coal.....	35°	35°	45°	50 lbs.	$90.34h^2$	$88.2h^2$	$19.8h^2$	5° 39′
Anthracite coal.....	27°	27°	45°	52	$78.7h^2$	$77.7h^2$	$11.4h^2$	8° 20′
Sand.....	34°	34°	45°	90	$159.\ h^2$	$154\ h^2$	$31.8h^2$	57° 4′
Ashes.....	40°	40°	45°	40	$80.6h^2$	$77.6h^2$	$21.5h^2$	60° 20′

$$\tan\delta = \frac{W}{P}, \quad E = \sqrt{W^2 + P^2}$$

$$Q = E\cos(\delta - a), \quad T = E\sin(\delta - a)$$

TABLES OF PRESSURES ON VERTICAL BIN WALLS.

The pressures on vertical bin walls under various conditions of surcharge and side-friction have been calculated from the preceding formulas for depths to from 1 to 30 ft. The results are tabulated in Tables I to IV herewith. The various columns in these tables have the following meanings:

Col. 1 gives the normal component of the total pressure on the (vertical) side, when the surface of the material is level. The bin side is assumed to be made of steel plate, i. e., ϕ' has values as given at head of the column.

Col. 2 gives the pressure against the vertical plane A B when friction is not considered, i. e., $\phi' = 0$.

Col. 3 gives the normal component of total pressure on a (vertical) side of steel plate, when the material is surcharged to the angle of repose, and the bin is unlimited in horizontal extent.

Col. 4 gives the same as Col. 3, but for the case where friction is neglected, i. e., $\phi' = 0$.

Col. 5 gives the normal component of the total pressure on a (vertical) side of steel plate, when the material slopes downward along the angle of repose, i. e., $\phi' = \phi$.

Col. 6 gives the same as Col. 5, but for the case where friction is neglected, i. e., $\phi' = 0$.

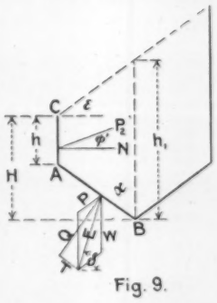

Fig. 9.

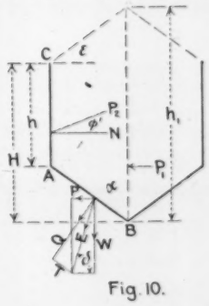

Fig. 10.

DIAGRAMS FOR CASES 5 TO 10.

Table of Constants for Steel-Plate Bins.—Case 6.

Material.	ϕ	a	w	E	Q	T	δ
Bituminous coal.....	35°	45°	50 lbs.	$25.88h^2$	$22.4h^2$	$12.9h^2$	74° 54′
Anthracite coal.....	27°	45°	52	$27.8h^2$	$25.3h^2$	$11.5h^2$	66° 6′
Sand.....	34°	45°	90	$40.8h^2$	$40.8h^2$	$22.87h^2$	74° 16′
Ashes.....	40°	45°	40	$20.16h^2$	$17.2h^2$	$11.07h^2$	77° 46′

STRESSES IN BINS.

After the pressures on the walls of a bin have been determined upon, the stress-analysis often gives rise to perplexity, due to the fact that the problem is somewhat different from those met with in the design of other forms of steel work.

TABLE I.—TOTAL PRESSURE FOR DEPTH "h" FOR BITUMINOUS COAL.
w = 50 lbs., $\varphi = 35°$.

Depth h	1	2	3	4	5	6
	$\varphi^1 = 18°$	$\varphi^1 = 0$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$
1	5.83	6.75	16.75	20.5	4.27	5.13
2	23.32	27	67	82	17.1	20.5
3	52.47	60.75	150.75	184.5	38.4	46.2
4	93.4	108	268	328	68.3	82
5	145.7	168.75	418.75	513	107	128
6	209.4	243	603	738	156	184.5
7	286	333	821	1,005	209	257
8	373	432	1,072	1,312	273	328
9	472	547	1,357	1,661	346	415
10	583	675	1,675	2,050	427	513
11	705	817	2,027	2,481	516	615
12	840	972	2,412	2,952	615	738
13	985	1,141	2,831	3,465	722	866
14	1,143	1,323	3,283	4,018	838	1,005
15	1,312	1,519	3,769	4,613	960	1,152
16	1,492	1,728	4,288	5,248	1,093	1,311
17	1,685	1,951	4,841	5,945	1,232	1,480
18	1,889	2,187	5,427	6,642	1,382	1,660
19	2,105	2,437	6,047	7,400	1,541	1,852
20	2,332	2,700	6,700	8,200	1,708	2,052
21	2,571	2,977	7,387	9,041	1,883	2,262
22	2,821	3,267	8,102	9,922	2,067	2,483
23	3,084	3,571	8,861	10,845	2,259	2,560
24	3,358	3,888	9,648	11,808	2,460	2,810
25	3,644	4,219	10,469	12,813	2,669	3,206
26	3,941	4,563	11,323	13,858	2,887	3,468
27	4,250	4,923	12,211	14,945	3,113	3,740
28	4,570	5,292	13,142	16,072	3,348	4,022
20	4,903	5,677	14,087	17,241	3,591	4,314
30	5,247	6,075	15,075	18,450	3,843	4,617

TABLE II.—TOTAL PRESSURE FOR DEPTH "h" FOR ANTHRACITE COAL.
w = 52 lbs., $\varphi = 27°$.

Depth h	1	2	3	4	5	6
	$\varphi^1 = 16°$	$\varphi^1 = 0$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$
1	8.39	9.75	20.05	23.17	6.38	7.1
2	33.5	39.0	82.0	93.3	25.5	30.0
3	75.5	87.8	184.5	208.6	57.5	68.5
4	134.2	156	328	371	102.0	122.2
5	210	244	513	579	159.5	191
6	302	351	738	834	230	267
7	411	478	1,005	1,135	313	374
8	536	624	1,312	1,482	402	489
9	680	790	1,661	1,876	517	619
10	839	975	2,050	2,317	638	764
11	1,014	1,180	2,481	2,802	773	925
12	1,209	1,405	2,952	3,340	920	1,100
13	1,418	1,648	3,465	3,918	1,080	1,290
14	1,643	1,910	4,018	4,540	1,250	1,497
15	1,887	2,193	4,613	5,220	1,436	1,720
16	2,145	2,500	5,248	5,930	1,636	1,953
17	2,421	2,808	5,945	6,696	1,845	2,207
18	2,718	3,160	6,642	7,507	2,064	2,471
19	3,030	3,521	7,400	8,363	2,310	2,758
20	3,350	3,902	8,200	9,268	2,554	3,053
21	3,700	4,303	9,041	10,218	2,820	3,372
22	4,061	4,718	9,922	11,214	3,086	3,701
23	4,438	5,156	10,845	12,257	3,372	4,040
24	4,833	5,611	11,808	13,346	3,680	4,398
25	5,244	6,097	12,813	14,481	3,985	4,770
26	5,672	6,600	13,858	15.663	4,521	5,160
27	6,116	7,112	14,945	16,891	4,650	5,560
28	6,578	7,638	16,072	18,165	5,000	5,979
29	7,056	8,202	17.241	19,486	5,370	6,421
30	7,551	8,775	18,450	20,853	5,742	6,880

The stresses in the plates and stiffness of the sides and bottom of the bin, and the stresses in the connections, are the principal divisions of the problem.

PLATES.—A number of formulas are available for the strength of flat plates supported along the edges.

Grashof gives the following for square plates:

$$w = 48\,\frac{t^2}{CL^2} \text{ or } S = \frac{w\,C\,L^2}{4\,t^2}$$

where w = uniform load for unit area.
S = maximum unit stress.
C = a constant = 1.125.
L = side of square.
T = thickness of plate.

Unwin gives, for flat circular plates:

$$S = \frac{2}{3}\,\frac{w\,r^2}{t^2}$$

where r is the radius of the circle

Reuleaux gives, for flat circular plates:

$$S = \frac{3}{2}\,\frac{w\,r^2}{t^2}$$

The "American Machinist," of July 25, 1901, gives for square and rectangular plates:

$$S = \frac{w\,b\,d}{8\,t^2}$$

A comparison of these formulas is given in Fig. 11, the formulas for circular plates being calculated for a diameter 2 r equal to the length of side of the square plates. A unit stress of 12,000 lbs. per in. is assumed.

Fig. 12 is a diagram for use in finding the thickness of plate between stiffeners, calculated from the "American Machinist" formula. This diagram is also based on a stress of 12,000 lbs. per sq. in. As an example: Find the safe load on a ¼-in. plate 4 ft. square. Begin at 4 on the bottom of the diagram, follow upward to the line for ¼-in. plates; from the intersection follow to the left and read 3.82, or 382 lbs. per sq. ft. To use this diagram for rectangular plates, assume that the plate is equivalent to a square whose side = $\sqrt{bd}$.

STIFFENERS.

If we assume that a vertical stiffener takes one-half the area on either side of it, and we wish to determine the maximum bending moment, we assume that we have a beam loaded by a wedge-shaped mass, the load being zero at the upper end and increasing to a maximum at the bottom. The strength of the beam loaded thus is practically the same as that of a beam uniformly loaded, and tables for this latter case can be used safely. The maximum bending moment is .129 Wh, practically. If we represent this triangle graphically we draw the base equal to 2 Kh, and the altitude or length of the stiffener equal to "h," since all the formulae are in the form of Kh^3, depending upon the angle of repose, the surface of the material, etc.

In case we have an intermediate stiffener, the lower section of the bin side would be loaded as shown in Fig. 13. We find that the reaction

$$R = \frac{2}{3}\,K\,(H-h)\left(\frac{H}{2}+h\right)$$

and

$$R_1 = \frac{2}{3}\,K\,(H-h)\left(H+\frac{h}{2}\right)$$

The maximum bending moment is equal to

$$Ry - K\,(2\,hy + y^2)\,(y - Y)$$

in which

$$y = \sqrt{\frac{2}{3}\,(H-h)\left(\frac{H}{2}+h\right)+h^2}-h$$

and

$$Y = \frac{2\,y\left(\frac{h}{2}+\frac{y}{3}\right)}{2\,h+y}$$

It will be useful to have a general formula for

TABLE III.—TOTAL PRESSURE FOR DEPTH "h" FOR SAND.
w = 90 lbs., $\varphi = 34°$.

Depth h	1	2	3	4	5	6
	$\varphi^1 = 18°$	$\varphi^1 = 0$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$
1	10.93	12.72	30.9	37.3	6.34	9.61
2	43.7	50.8	123.6	149	25.4	38.4
3	98.5	114.5	278	336	57.1	86.40
4	175	203.7	494	596	101.5	113.8
5	273	318	772	933	158.7	240
6	394	458	1,113	1,340	222.2	346
7	535	624	1.515	1,825	311	471
8	700	815	1,980	2,382	407	615
9	885	1,030	2,500	3,080	514	778
10	1,093	1,272	3,090	3,730	634	961
11	1,345	1,540	3,740	4,510	702	1,162
12	1,575	1,833	4,450	5,370	914	1,383
13	1,848	2,150	5,230	6,300	1,072	1,624
14	2,160	2,495	6,060	7,300	1,243	1,880
15	2,460	2,862	6,960	8,390	1,458	2,160
16	2,798	3,256	7,910	9,549	1,623	2,460
17	3,159	3,676	8,930	10,780	1,832	2,777
18	3,541	4,121	10,012	12,095	2,054	3,114
19	3,949	4,592	11,155	13,465	2,289	3,469
20	4,372	5,088	12,360	14,920	2,536	3,844
21	4,820	5,610	13,627	16,449	2,796	4,238
22	5,290	6,156	14,956	17,053	3,069	4,651
23	5,782	6,729	16,346	19,732	3,354	5,084
24	6,296	7,327	17,798	21,485	3,652	5,535
25	6,831	7,950	19,313	23,313	3,963	6,006
26	7,389	8,599	20,889	25,215	4,286	6,496
27	7,968	9,273	22,526	27,192	4,622	7,006
28	8.569	9,972	24,225	29,243	4,971	7,584
29	9,192	10,698	25,987	31,369	5,332	8,082
30	9,837	11,448	27,810	33,570	5,706	8,649

TABLE IV.—TOTAL PRESSURE FOR DEPTH "h" FOR ASHES.
w = 40 lbs., $\varphi = 40°$.

Depth h	1	2	3	4	5	6
	$\varphi^1 = 31°$	$\varphi^1 = 0$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon = \varphi$	$\varepsilon - \varphi$
1	3.44	4.35	11.73	15.32	2.53	3.23
2	13.76	17.4	47	61.4	10.13	12.9
3	30.96	39.2	105.7	138	22.8	29.01
4	55.04	69.6	188	245	40.4	31.7
5	86	108.7	294	383	63.2	80.8
6	124	156.4	423	552	91	116
7	168	213	576	751	124	158
8	220	278	751	980	162	207
9	279	352	952	1,241	205	261
10	344	435	1,173	1,532	253	323
11	416	526	1,420	1,856	306	391
12	495	626	1,690	2,210	364	465
13	581	735	1,985	2 596	428	546
14	674	852	2,300	3,030	496	634
15	774	978	2,640	3,450	569	726
16	881	1,113	3,010	3,925	648	828
17	994	1,257	3,400	4,440	730	934
18	1,115	1,408	3,803	4,971	820	1,045
19	1,242	1,527	4,240	5,540	914	1,165
20	1,376	1,740	4,700	6,140	1,013	1,290
21	1,517	1,920	5,181	6,772	1,118	1,423
22	1,665	2,100	5,677	7,414	1,225	1,561
23	1,820	2,300	6,215	8,104	1,340	1.706
24	1,981	2,506	6,756	8,824	1,460	1,860
25	2.150	2,720	7,331	9,575	1,582	2,017
26	2,325	2,940	7,929	10,356	1,714	2,180
27	2,508	3,165	8,551	11,168	1,847	2,352
28	2,697	3,406	9,196	12,011	1,984	2,530
29	2,893	3,660	9,865	12,884	2,131	2,718
30	3,096	3,915	10,557	13,788	2,282	2,910

unequal loadings of this kind, as shown by Fig. 14; this formula will be applicable to bin bottoms as well as sides. If we let "b" be the slope of the load line, a' b', we have

$$R = \frac{al}{3} + \frac{(a + bl)\,l}{6}$$

$$R_1 = \frac{al}{6} + \frac{(a + bl)\,l}{3}$$

The point of maximum bending moment is at

$$x = \sqrt{\frac{3\,a^2 + b^2}{3b} + \frac{a^2}{b^2}} - \frac{a}{b}$$

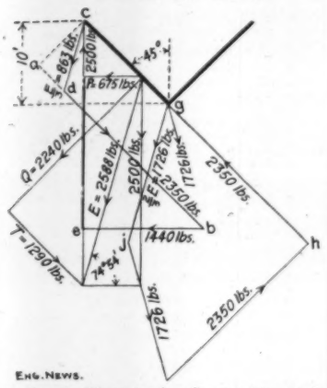

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Fig. 16. Stress-Diagram for Connections of Track Hopper.

The maximum bending moment is

$$M = Rx - \left(ax + \frac{b\,x^2}{2}\right)(x - X)$$

where

$$X = \frac{x\left(\frac{a}{2} + \frac{bx}{3}\right)}{a + \frac{bx}{2}}$$

where X is the abscissa of the center of gravity of the loading.

By properly representing the loading on the stiffener, this last formula can be made quite handy.

A very important consideration in the loading of stiffeners is the area of plate which the stiffener supports. A fair assumption is to consider the load on the stiffener to be as shown in Fig. 15, which is self-explanatory. We find for the reactions the following:

$$R = \frac{36\,d\,h^4 - 21\,d^2\,h^3 - d^3\,h^2 + \frac{2}{3}\,d^4\,h + \frac{d^5}{6}}{h\,(96\,h - 24\,d)} \times K$$

$$R_1 = \frac{60\,d\,h^4 - 51\,d^2\,h^3 + 13\,d^3\,h^2 - \frac{2}{3}\,d^4\,h - \frac{d^5}{6}}{h\,(96\,h - 24\,d)} \times K$$

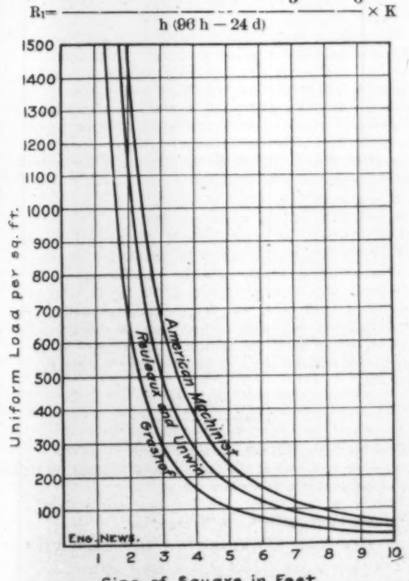

Fig. 11. Comparative Diagram of Formulas for the Strength of Flat Plates.

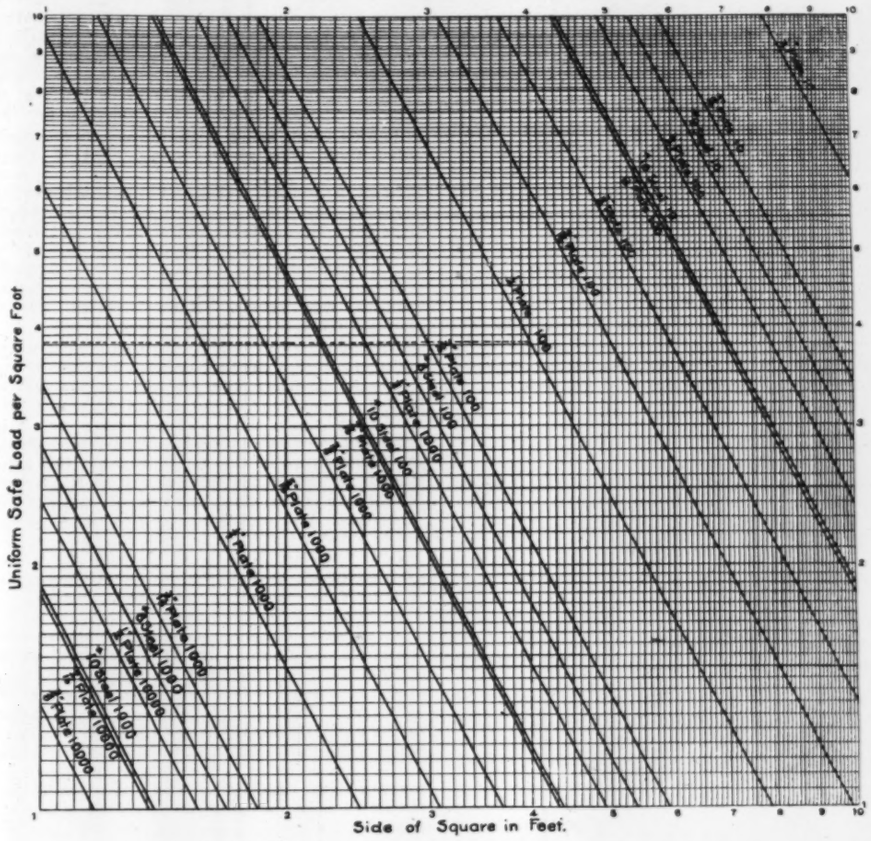

FIG. 12. DIAGRAM FOR FINDING THE STRENGTH OF FLAT PLATES.

Maximum Allowed Stress = 12,000 lbs. per sq. in.

If d = h, R = .206 Kh³ and R₁ = .294 Kh³.

If the section of maximum bending moment cuts through the central portion of the area shown in Fig. 15, and the distance from the reaction R is x, we have

$$x = \sqrt{\frac{36\,h^4 - 21\,d\,h^3 - d^2\,h^2 + \frac{2}{3}\,d^3\,h + d^4}{h\,(93\,h - 24d)} + \frac{d^2}{12}}$$

From this we get the maximum bending moment equal to

$$M = R\,x - \frac{K\,d^3}{6}\left(x - \frac{3d}{8}\right) - Kd\left(x^2 - \frac{d^2}{4}\right)\left(\frac{3x^2 + 2\,dx - \frac{5\,d^2}{2}}{8\,(d + 2\,x}\right)$$

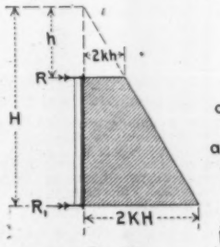

Fig. 13.

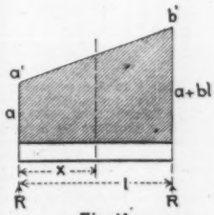

Fig. 14.

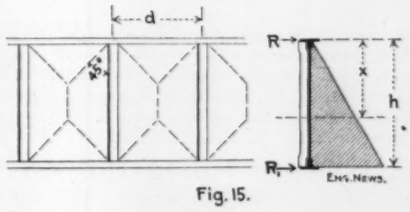

Fig. 15.

The above formulas are accurate for cases in which the width d is equal to or less than the depth h, but they are not applicable when d is greater than h. In this case consider that the area carried by the stiffener is the square cut off when d = h, and calculate the remaining area as being taken by the flanges of the bin girder.

STRESSES IN CONNECTIONS.—A discussion of one or two common cases in bin and hopper work will illustrate the method of procedure to be used in finding the streasses at angles and connections.

For the track hopper, Fig. 16, the resultant pressure E on the side is found by the formula of Case 6. The reaction at the corners are then $\frac{1}{3}$ E at the top, and $\frac{2}{3}$ E at the bottom. The forces about lower corner will be the tension in each plate and the forces $\frac{2}{3}$ E for each side. The polygon of forces about the lower corner is g j i h. The forces at the upper corner are c d (equal to $\frac{1}{3}$ E and parallel to E), d b (tensile stress in the plate from the lower corner, b e (the stress in the horizontal stiffener or strut across the top), and, lastly, e c, which is the vertical reaction of the bin support on this side. All these forces are taken for a bin one foot wide perpendicular to the plane of the cross-section. Evidently the diagram for the lower corner gives the tension in the plate,* while the diagram for the upper corner gives the pressure on the support and the stress in the top strut or tie.

For the bin whose cross-section is shown in Fig. 17, the load on the stiffener of side a g (stif-

*In Fig. 16, the total maximum tensile stress in the plate is a b, since the force c d = $\frac{E}{3}$ at the upper corner has the component a d in the direction of the plate.

feners parallel to the plane of cross-section) is first found. Draw a perpendicular m n at the middle of a g, making it proportional to

$$\frac{Q}{(H-h)\sec\alpha}$$

where Q has been found by the formula of Case 8. From o draw o n s through point n; then the trapezoid at s g will represent the loading of the stiffener. The reactions R and R_1 due to this loading are

$$R = \frac{at \times ag}{3} + \frac{gs \times ag}{6}$$

$$R_1 = \frac{at \times ag}{6} + \frac{gs \times ag}{3}$$

Lay off R and R_1 perpendicular to a g. The components in the direction of E (i. e., a b and g f) can be found next by finding the angle E makes with the horizontal (see Case 8.) We can

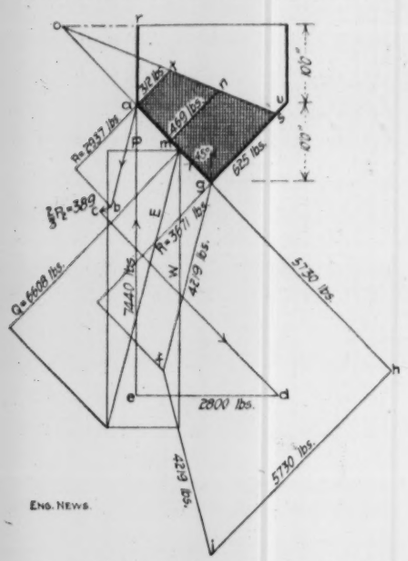

Fig. 17. Stress Diagram for Connections of Bin with Hopper Bottom.

now draw the force polygon g h i f for the lower corner, and design our riveted connections accordingly. The forces about the upper corner a will be as follows: Starting with the E component of the reaction R or a b, draw b c, which is the reaction due to the thrust against the vertical wall a r, and is equal to $-\frac{2}{3} P_2$ (Case 8). Next draw c d equal to g h (the stress in the plate from the bottom corner), then d e (the stress of the stiffener or strut across the bin, and depending upon the design of the bin), and, lastly, the force e a, which is the vertical load on the girder wall a r at the bottom joint a. From these forces the rivet spacing, connections, stiffeners, etc., can be designed. The stiffeners on a g can be designed from the formula for bending moment given previously, by substituting H sec α for H and h sec α for h, which makes l = (H − h) sec α. In the two examples just given the stresses marked on the diagrams are for bins filled with bituminous coal.

INVESTIGATIONS OF THE BLOWING OF FOUNDRY CUPOLAS.

The question of the best methods and appliances to be used in the blowing of foundry cupolas is one of the most important questions in relation to efficiency and economy of work, and has been given considerable attention by the various foundrymen's associations; but there is very little reliable information as to actual results. Some months ago a committee was appointed by the Pittsburg Foundrymen's Association to investigate this subject, but found this a matter of difficulty, since few foundrymen have the means for accurately determining the power, speed and air delivery of their blowers. A preliminary report was presented at the May meeting, but this report was mainly a compilation of replies to a circular letter of inquiry, and was therefore largely indefinite, and some of the figures given were evidently inaccurate. The twenty replies to the question as to the use of fans or blowers showed that thirteen of the foundries were using blowers and seven were using fans. The report states that if these figures are considered as representative they indicate a decided tendency towards the use of blowers. There is no uniformity in the connections from fan or blower to the cupola, and in one case the blower was 123 ft. from the cupola. A few of the replies reported a change from a fan to a blower, the reasons given being that the latter requires less power. None reported having changed from a blower to a fan.

The report states that it has been proved without question that the fan for certain purposes has a greater efficiency than the blower, but that it is still a question whether it has a greater efficiency for cupola work. To determine this, it is necessary to consider the amount of metal melted, the temperature of the metal, and the fuel consumed, as well as the original cost of the fan or blower, the power required to run it, and the depreciation. The replies received to the inquiries above noted are of little help for this purpose, and careful tests are now to be made at the works of Mackintosh, Hemphill & Co., of Pittsburg, Pa. A Sturtevant fan and a Connersville blower have been furnished for three tests.

By request of the same committee, the Buffalo Forge Co., of Buffalo, N. Y., also undertook to make an investigation, and the results have been stated in a paper which was presented by Mr. W. H. Carrier, Engineer of Tests of that company, at the annual meeting of the American Foundrymen's Association, held at Indianapolis on June 8. We are indebted to Mr. Carrier for a copy of his paper, an abstract of which is given below. He states that the value for horse-power and air supply have been carefully checked in practical operation.

The air required per ton of iron melted has been variously given as from 30,000 to 33,000 cu. ft. As it is almost impossible to measure the air directly, it is necessary to resort to indirect methods of chemical analysis of the escaping gases. By analyzing a sufficient number of samples the amount of air used in the combustion of the coke can be determined with considerable exactness. This also serves to show the nature of the gases produced. In Table I. are given the results of several analyses:

TABLE I.—Analyses of Gases from Factory Cupolas.

No.	Pressure.	CO_2 %	CO %	Oxy. %	Nit. %	Air, per lb. carbon.	Air, per lb. coke.	B.T.U. per lb.
1	14 oz.	11.0	10.0	0.6	78.4	9.15	8.1	8,530
2	14 oz.	11.6	10.5	2.1	75.8	9.95	8.8	8,540
3	14 oz.	13.4	10.4	0.3	95.9	9.3	8.2	8,800
4	14 oz.	11.0	14.3	0.5	74.2	8.83	7.8	7,750
5	16½	10.5	10.4	0.8				
6	16½	10.5	10.4	0.8	78.3	9.15	8.24	9,420
7	16½	12.3	10.7	0.9	71.0	9.34	8.4	9,800
8	16½	12.4	10.0	0.3	76.3	9.07	8.16	9,960
9	16½	11.2	11.9	0.4	76.5	8.4	7.55	9,300
10	16½	12.0	15.0	1.0	72.0	8.57	7.7	8,850
					Aver. =	8.9	8.00	9,466
11	9	15.0	8.8	0.4	75.8	9.5	8.55	10,700
12	9	12.9	10.5	0.4	80.2	8.85	7.96	10,500
13	9	17.5	6.7	0.1	75.7	9.87	8.89	11,930
14	9	9.3	12.2	0.4	78.1	8.7	7.83	8,725
					Aver. =	9.23	8.31	10,394

Nos. 1 to 4 are from a 44-in. cupola operated by Buffalo steel pressure blowers at 14 ounces pressure. Nos. 5 to 10 are from a 60-in. Whiting cupola operated at 16½ ounces pressure by a positive blower. Nos. 11 to 14 are from the center-blast 74-in. Whiting cupola at the plant of Thomas D. West Foundry Co. This cupola was operated by a Buffalo blower at 9 ounces pressure.

It will be noted that an average of about 9 lbs. of air are required per pound of carbon, and with coke containing an average of 90% carbon, this will be 8.1 lbs. of air per pound of coke. It will also be noted that in the majority of samples, only about 50% of the carbon is burned to carbon dioxide; the remaining portion is burned to carbon monoxide, and liberates only one-third of its total heating value. One pound of carbon burned to carbon dioxide requires practically 12 lbs. of air for combustion; the same burned to carbon monoxide requires only 6 lbs. of air. In the first process 14,450 heat units are liberated, but in the second process only 4,400 units. From this it will be seen that in the present cupola practice less air is given than that necessary for perfect combustion; and only about 66% of the total heating value of the fuel is utilized; the remaining 33% escaping in the unburned carbon-monoxide gases. The deeper and more intense the fire, the greater seems to be the percentage of carbon monoxide gas produced. In blast furnace practice this gas is present in quantities sufficient to make the gases highly valuable as fuel, either in the production of steam or for use in gas engines. While this discussion is somewhat foreign to the general purpose of this paper, it may be remarked that there is an opportunity for effecting considerable saving in fuel and consequent increase in the melting ratio by devising some means whereby a more perfect combustion may be secured. The above test, so far as conducted, would indicate that the center-blast tuyere first proposed and tried by Mr. Thomas D. West is a step in the right direction. The samples of gases taken from this cupola except the last, show a much more perfect combustion than the ordinary side blast cupola.

From the above consideration it appears that the amount of air required per ton of iron depends upon and varies with the melting ratio. The following weights and volumes of air are required per ton of iron, for different melting ratios:

Melting Ratio.	By Analysis. Wt. of Air, lbs.	By Analysis. Vol. of Air, cu. ft.	Perfect Combustion; Volume of Air, cu. ft.
7	2,320	31,000	41,400
8	2,020	27,000	36,000
9	1,800	24,000	32,000
10	1,620	21,600	28,000
11	1,470	19,500	26,200
12	1,350	18,000	24,000

The above volumes of air are estimated on an average temperature of 70°. Coke is taken as 90% carbon.

SPEED OF MELTING.

The pressure required to give a stated melting capacity with a given sized cupola cannot be stated absolutely with any degree of exactness. This depends upon the melting ratio, the method of charging, and the nature of the coke and iron used. In general, soft coke requires less pressure than hard coke, but does not give as good results. The speed of melting is decreased by the presence of large quantities of scrap or steel in the charge. However, if we take a standard method of charging, comprising a definite ratio of coke to iron and a definite percentage of scrap of uniform size, the variation in speed of melting which will be produced by different pressures follows quite exact laws. Taking a standard charge, the following results will be obtained from a 44-in. cupola, when operated at various speeds.

Pressure, oz.	Speed of Fan. Revs. per min.	Speed of Fan. Peripheral ft. per min.	Air per minute, lbs.	Est. Melt. Capacity, tons.	Horse Power.
10	2,151	16,193	3,100	6.0	16
11	2,254	16,966	3,250	6.4	18
12	2,362	17,702	3,400	6.7	21
13	2,450	18,405	3 540	6.9	23
14	2,535	19 081	3,670	7.2	26
15	2,620	19,730	3,800	7.5	29
16	2,705	20,358	3,920	7.8	32

From the above it will be seen that the resistance of the air offered by the cupola follows the general laws of fluid friction; that is to say, the amount of air forced through the cupola will vary as the square root of the pressure. For example: If we force twice the amount of air through the cupola then the pressure will be increased four times, and if the pressure in increased nine times, then three times the amount of air will be forced through. Since the speed of melting with a fixed melting ratio must necessarily be proportional to the amount of air supplied to the cupola, we will have the speed of melting varying as the square root of the pressure.

The melting capacity of a cupola with a given pressure depends upon its size and is nearly proportional to the area of the cross section; hence to the square of the diameter inside the lining. This will not hold exactly with the ordinary side-blast tuyeres, as somewhat larger pressure is required with the large sizes of cupolas to force the air to the center of the charge. As a result of a number of tests the following formula is determined for the average speed of melting:

$W = 2\,D^2\sqrt{p}$.

W = Weight of iron in lbs. per hour.

D = Diameter of cupola, inside lining, in inches.

p = Pressure at the cupola in ounces per sq. in.

This formula holds with a considerable degree of exactness for melting ratios of 10 to 1 with a good quality of hard coke, and for charges containing only a small amount of scrap. Variations in these conditions will of course vary the results. The air per minute required for various sizes of cupolas may be given by the formula:

$$C = \frac{D^2 \times \sqrt{p}}{2}.$$

C = the cubic feet of air per minute required.

D = the diameter of the cupola, inside lining, in inches.

p = the pressure in ounces per sq. in.

This is a safe factor for ordinary use and gives an allowance of about 10% for leakage, etc.

HORSE-POWER REQUIRED TO OPERATE CUPOLA.

It is usually considered that a certain sized fan, operating at a certain pressure, will require a certain horse-power. This is the usual method of rating given by makers. This rating holds very well when the fans are

determining the amount of air specified at the given pressure, but there is considerable fallacy in using this as the correct horse-power when applied to cupolas in ordinary practice, since the amount of air which the blower will handle is limited by the size of the cupola; and the horse-power required to operate the fan is dependent upon the amount of air which it is allowed to handle.

Each cubic foot of air per minute moved against a pressure of 1 ounce per sq. in., or 9 lbs. per sq. ft., represents the expenditure of 0.000272 HP; that is, with perfect efficiency, 37,000 cu. ft. of air per minute moved against 1-ounce pressure, will require 1 HP. A well-constructed fan will give a maximum efficiency of about 60%; therefore we will have 0.00045 HP. per cu. ft. of air per minute per ounce pressure. The horse-power required for any sized cupola at any pressure is given by the formula:

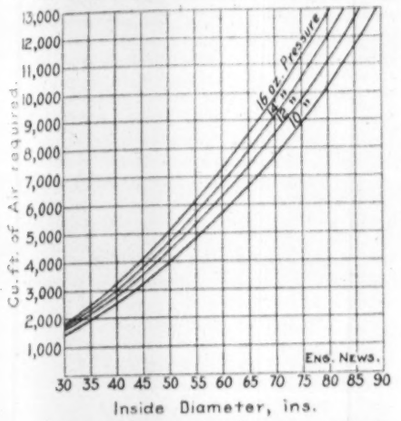

Fig. 1. Diagram Showing Air Required for Foundry Cupolas.

$$HP = \frac{D^5\sqrt{p}}{3{,}800}$$

D = the diameter of cupola inside of lining in inches.

p = the pressure at the cupola in ounces per sq. in.

The diagrams in Figs. 1 and 2 show the graphical results, and are very convenient for reference.

PERFORMANCE OF CENTRIFUGAL BLOWERS.

The statement has already been made that the air delivery and horse-power of a centrifugal blower at a given pressure depends upon the size of the cupola to which it is applied. In this respect the centrifugal blower varies greatly from the positive pressure blower. With the latter, as the resistance is increased (either by increasing the speed of the blower or applying it to a smaller cupola) the pressure and horse-power are both increased in proportion. In the centrifugal blower the effect upon the horse-power is reversed. With the increase of resistance the pressure is increased as in the positive blower, but the capacity and horse-power are both decreased. If the resistance against which the centrifugal blower is working is decreased, as by putting on a lighter charge, or applying it to a larger cupola, the pressure is decreased to a certain extent, and the capacity and horse-power are increased. In this respect the centrifugal blower offers some advantages over the positive blower. The rotary blower, while positive in action, is limited in capacity, and cannot adjust itself to the variations in demand for air; nor can its capacity and pressure be readily controlled by the operation of a blast gate, as with a centrifugal blower. The flexibility of operation secured with the centrifugal fan often makes the melting capacity of the cupola with a fan blower considerably greater than with a positive blower, owing to the fact that an increased quantity of air can be supplied when required. Another advantage of the centrifugal blower is that the same size can be applied to several sizes of cupolas without altering the speed and without greatly affecting the efficiency of the blower.

The horse-power required for a centrifugal blower when running open is about twice as much as that required when operating at rated capacity; and when running closed it is only 28% as much as that required at rated capacity, or 14% of the horse-power required at free delivery. The increase in horse-power is also proportional to the increase in capacity. The pressure increases from free delivery up to about 60% of the rated capacity; from 60% of the rated capacity to the closed outlet the pressure again decreases, which shows that the maximum pressure is secured at 60% rated capacity. The rated capacity of the blower is based upon the capacity and pressure at which it will operate most economically.

As has been shown, the capacity under any condition is proportional to the speed of the fan, and the pressure is proportional to the square of the speed. From this it follows that the horse-power required to drive the fan will vary as the cube of the speed. Suppose that a cupola blower operating at 1,800 revolutions per minute requires 25 HP. when attached to a certain cupola. Now if the speed is increased from 1,800 to 1,980, or 10%, then the horse-power will be increased 1.33 times, or an increase of 33%, which will make 33.3 HP. at 1,980 revolutions. Also, if a blower gives 10 ounces pressure at 1,800 revolutions, when applied to a certain cupola, it will give 1.21 times that pressure for an increase of 10% in speed; that is, at 1,980 revolutions the pressure will be 12.1 ounces.

EFFECT OF PIPING RESISTANCE.

The piping connections from blower to cupola affects considerably the results secured. With a short, straight pipe the pressure at the cupola will be practically the same as at the fan outlet. If, however, the connection is long and has a number of sharp bends, the pressure may be reduced several ounces. If the speed of the fan is not increased the horse-power will be decreased by this

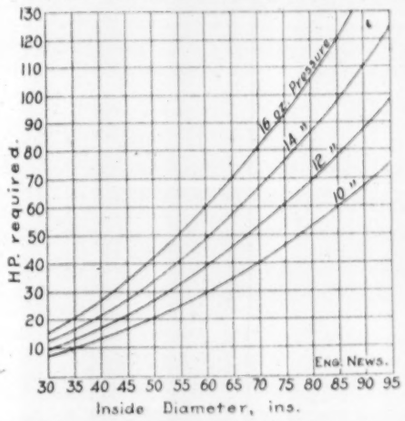

Fig. 2. Diagram Showing HP. Required to Operate Foundry Cupola Fans.

resistance, but the melting capacity of the cupola will also be decreased. The pressure at the fan outlet will be slightly increased by the extra resistance offered by the fan. If, however, the fan is speeded up to secure the desired pressure at the cupola, then a considerably increased horse-power will be required to overcome the extra resistance of the piping.

SUMMARY.

The following main points in fan cupola practice should be emphasized:

(1) The horse-power required to operate a cupola at any stated pressure is, to a certain extent, independent of the size of the blower so long as it has sufficient capacity to supply the required amount of air.

(2) The melting capacity of the cupola under standard conditions varies with the pressure according to fixed laws.

(3) More horse-power is required per ton of iron melted at the higher pressures than at the lower pressures.

(4) At a fixed speed the greatest horse-power is taken when the blower is running wide open, or at free delivery; the least horse-power is taken when the outlet is closed. The increase in horse-power is proportional to the increase in air delivery.

(5) The piping resistance decreases the air delivery and decreases the horse-power at a fixed speed, but increases the horse-power when the fan is speeded up to give the same pressure at the cupola.

(6) The centrifugal blower presents some advantages over the positive blower, from the fact that better results can be secured at lower pressures, there is a greater uniformity of blast pressure, and it offers a flexibility in regulation. With the exception of the belting there is but little wear or deterioration. On the other hand, the positive blower, owing to the friction of the contact surfaces, wears and deteriorates rapidly, and its effect while high at the beginning, decreases rapidly, owing to the leakage caused by the wearing away of the contact parts.

A SUGGESTED STANDARD NUMBER-CODE FOR HYDRANT AND FIRE-HOSE COUPLINGS.

By C. E. Loetzer.*

There can be no difference of opinion on the question that a standard or uniform size and thread for fire hose couplings ought to be used throughout the United States, if not the entire world. Unfortunately, however, such is not the case, and we are confronted with the cold fact that a multiplicity of sizes does exist, varying by every possible fraction from 2 5-16 ins. to 3¼ ins. outside diameter of male thread, using 8, 7½, 7, 6 and 5 threads per inch.

These varying sizes and threads are so promiscuously distributed that in many cases the extremes are found in neighboring cities and towns. That this state of affairs is to be regretted is unquestioned, and the evil results therefrom in cases of large fires are matters of abundant history.

Why is there no uniform hose coupling size; how come this multiplicity of sizes to exist; how can this evil be remedied or eliminated? These are questions invariably asked and have commanded the serious consideration of all interested parties, organizations, as well as some law-making bodies, for many years, always with the same result, that of leaving the matter unsolved. As far back as 1879 the International Association of Fire Engineers, at its 7th Annual Convention, adopted the "National" hose coupling size and thread, which is 3 7-32 ins. outside diameter of male thread and 6 threads per inch, the universal installation of which that body desired and recommended. Since that action was taken 25 long years have come and gone, and we are justified in making the query, has the "National" size been universally adopted? If not, why not? If there is even a single instance on record where a city or town in all those years actually changed from some other to the "National" size, such case is not known to the writer, and of the many towns and villages who have since installed fire hydrants and apparatus but very few have adopted that size. If the International Association of Fire Engineers, the highest fire tribunal, an organization made up of the best and most competent fire chiefs, men who are most directly interested and are in full charge of and in closest touch with this matter, if this body, made up of such men, have in all this time been able to accomplish so little, practically nothing towards the adoption of a uniform size, it would seem conclusive evidence that such change is exceedingly difficult, if not impossible, to bring about.

Supposing, however, that such change were possible, would the attending conditions warrant it as a wise move? We doubt it. Such attempted change would only result in crippling and disorganizing fire apparatus and departments for an indefinitely long period of time. It must be borne in mind that the making of this change means the removal of the couplings from hose and the placing of new ones, taking out the discharge nozzles from hydrants and inserting new ones, changing threads on engines, etc., etc. It further means that during the process of this change there would be some hose with old couplings and some with new, some hydrants with old nozzles and some with new, some engines with old and some with the new threads, and some hydrants and hose without either couplings or nozzles. Imagine, if you can, the amount of confusion this would produce and how seriously handicapped the departments would be under these conditions in case of fires, especially large ones. Now, consider, if you please, what a gigantic undertaking the making of such change would be for a city like New York, Chicago or a whole state, and it will readily be understood that an extremely hazardous state of affairs would exist, limited only by the size of the territory effected. Can any city, state or whole country afford the risk? Would it not literally be "jumping out of the frying pan into the fire?"

Why is there no uniform hose coupling in use and how came this multiplicity of sizes to exist? This was not a matter of intent or design, but of development, owing to the lack of concerted, intelligent action on the part of the manufacturers in their and our country's early history. When our country was young and the many of our present large cities and towns sprang up and began to grow, the need of fire apparatus became felt. This caused enterprising men here and there to engage in the manufacture of such appliances in a small way. Each of these used his own peculiar idea as to diameter and number of threads for couplings, regardless of what the other fellow was making, and in each case differing from that of the other maker. Then, too, the lack of precision gages and tools and the crude methods employed by the early manufacturers, together with the necessity for loose fits between male and female threads, resulted in still further variations from time to time in the same maker's goods. In some cases even manufacturers, after having put out a certain size for years, have radically changed to some other size, still regardless

*Towanda, Pa.

of those put out by the other makers. These makers, all bidding for trade, would, of course, sell their goods wherever possible. The goods of one maker would become installed in a certain city, those of another with its different hose size in a neighboring city, and those of still another in a third city, and in this way the many varying sizes become promiscuously distributed, so that to-day we find, for instance, 3-in. 8-threads as the adopted size in a given city, while that of its nearest neighbor is 3¼-in. 6-threads, and so on.

The factor most productive of evil, and the one that still further multiplied the already large number of varying sizes originated by the manufacturers, and responsible for the innumerable decimal fractional differences in existence, is the method of sending hydrant caps and parts of old couplings to manufacturers for use as sizers to fit new work to. As there has heretofore been an utter lack of system in the sizers in use no generally recognized data or identification marks employed, and as the fit between male and female parts must of necessity be loose, it is easily seen that such cap or coupling would prove an exceedingly "unknown quantity" as a sizer. If such sizer happened to be a hydrant cap or female coupling, it would almost invariably result in the new work being a trifle over size, owing to the play it contained. In case a male coupling was furnished, there would be a possible chance of the new work being correct, but by no means a certainty. If the male coupling proved a trifle over or under size, in all probability the new work fitted to it would be correspondingly inexact.

While I have in a general way pointed out the difficulties to be surmounted in the effort to establish a uniform size, and the extreme hazards of the undertaking pending such a change, I do not say that the accomplishment of such change is impossible; but I do assert that such change is improbable and unwise. If the evil cannot be entirely removed it can be remedied and reduced to a minimum. This ought and can only be accomplished through the concerted, intelligent efforts of all manufacturers making such goods. Not only will such a course prove a benefit to the country, but it will also be a great convenience and source of economy to the manufacturers. There is, therefore, no possible excuse for continuing to follow the long practised, crude and expensive methods of the past.

A careful study of the appended system of hose-thread sizers will show how this can be accomplished. This method has been originated by the writer, has been in use for some time, and is working with entire satisfaction. It reduces the evil to a minimum; standardizes the existing varying sizes, and eliminates the many fractional sizes between each two sizers without, in any manner, proving annoying to either maker or user.

Work, especially hose couplings made according to this system and stamped with its sizer number, will always bear its record of identification, regardless of how old it may become or how badly worn or mutilated it may be. Its sizer number will always show its original and correct size and thread, and will prove a reliable guide for duplicate work in the future. As there is no copyright, patent or string to this whatever, the writer sincerely urges its adoption upon all manufacturers, for their own and the country's general good, and will be glad to furnish any assistance that may be desired in its installation.

Loetzer's System of Fire Hose Thread Sizers.
Diameters of male thread and number of threads per inch.

Sizer No.	Diam. ins.	Threads.	Sizer No.	Diam. ins.	Threads.
1	3	8	16	3 1-32	7
2	3 1-32	8	17	3 1-16	7
3	3 1-16	8	18	3 3-32	7
4	3 3-32	8	19	3⅛	7
5	3⅛	8	20	3 5-32	7
6	3 5-32	8	21	3 3-16	7
7	3 3-16	8	22	3	7½
8	3 1-16	6	23	3 1-32	7½
9	3 3-32	6	24	3 1-16	7½
10	3¼	6	25	3 3-32	7½
11	3 5-32	6	26	3⅛	7½
12	3 3-16	6	27	3 5-32	7½
13	3 7-32	6	28	3 3-16	7½
14	3¼	6	29	3¼	5
15	3	7			

The above numbers refer to male sizer and threads. Make all male threads the exact diameter of sizer and female threads to contain the play. Stamp sizer number on both parts. For slight variations from above sizes, make male threads to next smaller sizer, and female threads to next larger sizer. A play of 1-64-in. to 1-32-in. between male and female threads must be allowed in all cases. Angle between threads, 70°. Sizes not within above range should be designated as "special" and marked "S."

THE COAL STORAGE AND COAL HANDLING PLANT AT THE NEW YORK NAVY YARD.

By Jos. S. Shultz, U. S. N.*

Rapid strides have been made during the last decade along all lines of engineering, but in none has the development been more pronounced than in that relative to the handling and storage of coal. The keen business competition existing among the many rival companies engaged in the manufacture of this class of machinery has produced almost incredible records. Take, for instance, an installation in Pittsburg, where coal is removed from barges, conveyed across intervening railroad fracks and industrial works to a plant situated over a mile from the water's edge. Another apparatus in New York removes coal from cars or colliers and stores it in open piles at the rate of 800 tons per hour. No less remarkable are the devices employed for storing and delivering the fuel used in the power plants located in our cities where the amount consumed is very large, and the available space for storage very small.

Coincident with this industrial development has been the increase in the facilities for furnishing the coal used and for storing the necessary reserve supply upon which depend in great part the strength, efficiency and ready availability of our new navy. The conditions, however, confronting the designer of coaling plants for the navy are greatly different from those existing in commercial and industrial enterprises.

Usually space is the least important consideration, but the depth of coal stored must be limited to 18 or 20 feet, for beyond that depth spontaneous combustion is likely to start disastrous fires; and even with this depth the dead coal space must be reduced to an absolute minimum in order that practically all of the coal may be reached and removed quickly in case such a fire should occur. Another important difference is the condition under which the machinery equipment of a naval plant operates. During the intervals of storing and removing coal it must work with maximum speed and efficiency, but ofttimes months will intervene between periods of operation. Therefore, in an industrial plant the moving parts must be designed for constant use, and those for naval purposes, in addition to being proportioned for the working intervals, must be made to resist the effects of disuse so as to be immediately available at any time. The distinctive features of a coaling plant for the navy, however, are the provisions that must be made in its design to insure the operation of coaling vessels to proceed at the maximum possible rate. The removal of coal from the collier or railroad car to the storage bins is governed only by the capacity of the conveying apparatus. Here then, as in a commercial plant, speed is the most essential consideration. Rapid delivery of coal to the vessel, however, will not alone result in rapid coaling. A war vessel of whatever class is primarily a fighting machine, and every detail is designed with that end in view. Consequently the coal passages are too small and the bunkers too inconveniently located to permit coaling directly from the storage bins. In short, instead of taking the coal from the bins in large quantities, it must be taken in lesser amounts from a large number of openings and delivered to the vessel in chutes, deck buggies, bags, baskets, etc., so that the entire crew and all of the many openings to the bunkers may be utilized and also so that every possible means can be availed of to facilitate the disposal of the coal after it reaches the bunkers.

The United States now possesses a number of coal depots constructed along the lines indicated above, and so located as to be readily accessible for coaling its various squadrons of war vessels. One of the best equipped of these, and consequently one of the most distinctive type of coaling plant, has just been completed at the U. S. Navy Yard, New York.

It is built on a pier 68 ft. wide, extending out into the East River for a distance of 500 ft. To a level of 1 ft. above mean low water, this pier is built of timber, all of which is of long-leaf yellow pine, except the piles, and being thus kept constantly wet is the most durable material possible for such a foundation, since neither the teredo navalis nor the limnoria terebrans exist in the New York harbor. The mean depth of water varies from 30 ft. at the inshore end to over 40 ft. at the outer end—the piles all being from 65 to 70 ft. in length and of the best Virginia pine. These are driven in bents, which are 4 ft. apart, and extend transversely across the pier. The number of piles per bent is alternately 12 and 22, and two 6 × 12-in. wales are used to tie the piles together.

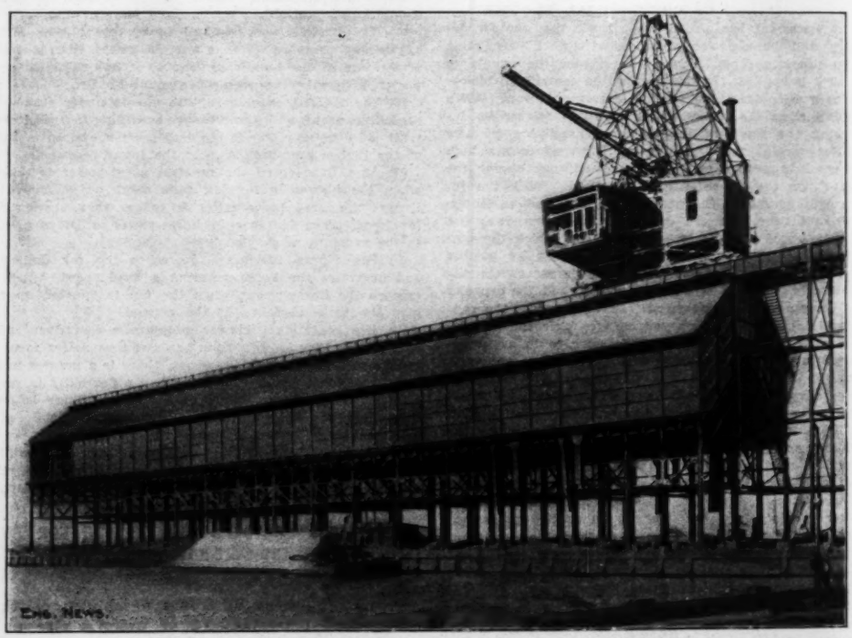

FIG. 1. VIEW OF COAL STORAGE AND COAL HANDLING PLANT AT THE NEW YORK NAVY YARD.

*U. S. Navy Yard, New York City.

Upon these a timber floor 5 ins. thick has been laid over the whole surface of the pier. Around the three sides and within 36 ins. of the face of the pier have been driven round piles in an absolutely close row, thus forming a completely enclosed space in the interior of the pier. In order to afford the requisite stiffness to this structure, for no batter piles were used, carefully selected riprap varying from 4 to 15 ins. in size was dumped in

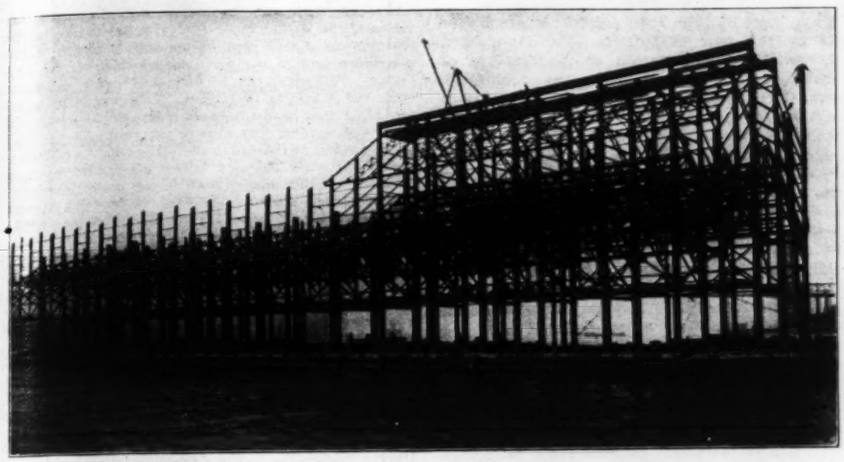

FIG. 2. STEELWORK OF NEW YORK NAVY YARD COAL STORAGE PLANT IN COURSE OF ERECTION.

this space before the floor was applied and very thoroughly tamped. This required over 15,000 cu. yds. of broken stone and made the timber foundation perfectly rigid and of ample strength to resist the terrific pressures likely to be brought to bear upon it when East River tides vent their force against two 16,000-ton battleships moored alongside for coaling.

Upon the top of the timber structure around the three sides has been built a concrete quay wall 8 ft. high and 10 ft. thick of 1:2:4 concrete faced with a granolithic finish 2 ins. thick. Within this wall are the concrete piers supporting the steel columns forming the struts of the coaling plant proper. As a further precaution against undue motion these piers are all connected by concrete ties 15 × 60 ins. in section, in each of which are embedded two 1¾-in. steel rods. Additional bearing piles were driven under these pier bases so that the maximum load carried per pile is not more than 10 tons. In the space intervening between piers and quay wall carefully selected earth was placed and then well tamped, over which a granite block pavement has been laid, thus making the whole level with the coping of the pier.

This pier was constructed under the supervision of Civil Engineers Asserson and Bellinger, U. S. N., by the navy yard force of workmen, and cost complete $87,000.

The superstructure of the coal storage and coal handling plant is of concrete and steel throughout, the elimination of all timber work thus minimizing the liability of fire. The building consists of 17 enclosed bays, each 20 ft. long, and two open bays of the same length at the inshore end, whose purpose will be hereafter described. These latter are each composed of two columns, which are made up of two 9-in. channels and two 10-in. × ¼-in. plates and are braced longitudinally on each side by three lines of two 5-in. laced channels and transversely by three 9-in. horizontal I-beams and intermediate crossed angles. As these columns are 76 ft. high, this elaborate system of bracing is required to provide the requisite rigidity. All of the columns rest upon cast-iron bases anchored securely to the concrete piers.

Forming the supports for each bay of the enclosed portion of the building are four Z-bar columns, the inner two containing 110 sq. ins. of metal each, and the outer ones 47 sq. ins. A strong interlocking system of angle and I-beam bracing connect these columns transversely and longitudinally from the floor of the bins down to a point 16 ft. above the coping of the pier and below this the pier is absolutely unobstructed except for the columns themselves, which condition, it will be seen later, is utilized to great advantage in the operation of coaling.

In order to eliminate all dead coal space, the floor slopes from the center downward toward each side at an angle of about 37°, the angle of repose of bituminous coal, and the central line of the floor is 51 ft. above the surface of the pier. Twelve-inch I-beams running longitudinally through the building and spaced 5 ft. 6 ins. on centers form the main support of this floor, which is a concrete-steel construction composed of 6 ins. of cinder concrete and a 1-in. granolithic top surface, the metal reinforcement being ½-in. corrugated bars spaced 6½ ins. c. to c. This floor is designed for a working strength of 2,400 lbs. per sq. ft. and it is made of one part cement, two parts sand and four parts clean anthracite boiler cinders. Extreme care was exercised in laying

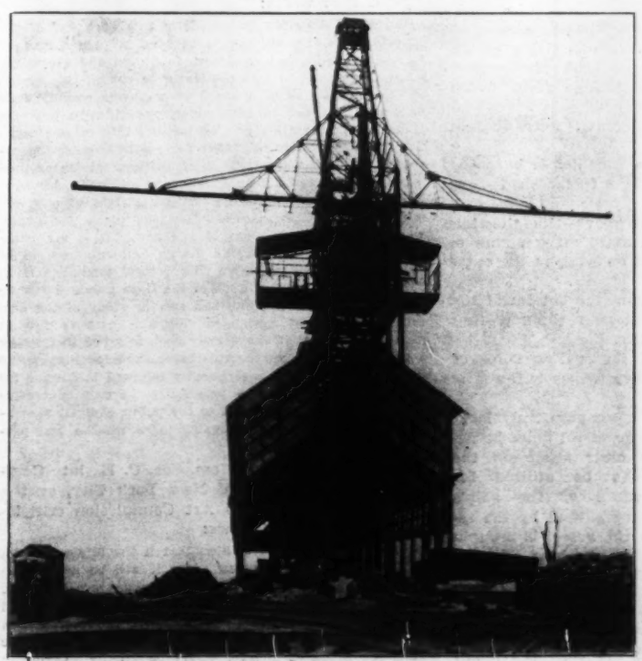

FIG. 3. VIEW OF INSHORE END OF COAL STORAGE PLANT SHOWING TRAVELING TOWER.

this concrete, for the steep slope made the work most difficult. Only the best grades of Portland cement conforming to U. S. Navy standard specifications were used, and the total cost of the floor in place was 25 cts. per sq. ft. In the sides of the coal shed between the columns are framed 6-in. horizontal I-beams spaced 5 ft. apart, and on this, leaving the steel skeleton exposed on the exterior side, is hung a 4-in. wall of cinder concrete embedded in which is an electrically-welded wire cloth of No. 3 and No. 10 B. and S. gage wires, with 3-in. × 8-in. meshes. This wall extends up to with 2 ft. of the eaves, which are 52 ft. above the coping level.

As a means of isolating a fire, dividing walls of 8-in. cinder concrete extend at each column bent transversely across the bins from the floor to within 4 ft. 6 ins. of the roof, 6 and 7-in. I-beams forming the main support, and two layers of wire cloth, similar to that used in the walls, serving as the metal reinforcement. The allowable depth of coal is 18 ft., and the plant is really composed of 17 separate bins with a capacity of 525 gross tons each of bituminous coal.

In spite of every precaution, however, a fire may originate in this coal, and, therefore, the Government has installed 34 thermostats, two in each bay, which are enclosed in galvanized pipes 4 ins. in diameter and 20 ft. long, and so hung that the thermostats may be moved throughout the whole depth of coal. Each is electrically connected to an annunciator located on the pier near a sentry box, so that a constant watch can be kept on the temperature of the stored coal.

The roof consists of two sloping sides between the outside columns parallel with the floor and a central horizontal section. It is covered with No. 20 gage corrugated galvanized steel. Extending eaves prevent snow and rain from entering the spaces at the top of the walls, which are left open to give free ventilation. On the top of each of the two central lines of columns is a 30-in. plate girder running the entire length of the 17 enclosed bays and out over the two open ones at the inshore end of the plant. These girders form the supports for the track of the traveling tower, which is thus capable of moving over the whole length of the building. The tower is of heavy steel construction, heavily braced, consisting of a main A-frame 92 ft. high above the tower rails and two booms extending out on each side to a distance of 75 ft. from the center, each boom being hinged at a point over the edge of the pier in order to provide for lifting it out of the way when not in use. Means for unloading a barge at each side of the pier is furnished by the two one-ton Rawson buckets, supported on trolleys, which run from the ends of the booms to the center of the tower. The hoisting of these buckets and the movement of the trolleys are accomplished by a direct-acting, quadruple cylinder engine actuating three 24-in. drums. A small vertical 7-in. by 8-in. engine furnishes the necessary power for raising the booms and for moving the tower, which is accomplished by a system of gearing to one set of the 16 cast-steel wheels supporting the tower. A vertical 100-HP. boiler supplies the steam required, and a 1,000-gallon steel tank contains the water from which the boiler is fed, this water being raised by an electrically-driven triplex plunger pump. The double system of operating levers located at the extreme ends of the engine room so that the buckets can be kept constantly in view completes the machinery equipment of the tower.

The buckets are arranged to dump into a large receiving hopper of 11 tons capacity, located in the center of the tower. This hopper is closed at the bottom with a strong double valve, arranged to be steam-operated and controlled from the dis-

tributing car, which runs underneath the tower on a standard gage railroad track extending the whole length of the storage bins. A 7½-HP. motor of the railroad type furnishes power for moving this car, which consists essentially of a steel hopper of 5 tons capacity, supported on a recording scale. This car is designed to distribute 60 tons of coal per hour, the coal being dumped between the rails through hatches with removable covers, and is controlled by one operator, who sits immediately in front of the scale beam and, therefore, checks the weight of all coal delivered to the bins.

In order to unload from railroad cars, two tracks have been laid on the pier near the edges and the coal delivered by these is dumped into a track pit of 30 tons capacity, built of timber lined with ¼-in. steel plate and thoroughly waterproofed. This pit is located in the open bays at the inshore end, and to remove the coal from here to the bins the tower is moved out on these bays, it then being possible to operate the buckets in the same manner as when coal is taken from barges.

In all there are about 1,010 tons of steel entering into the construction of this plant, which it cost approximately $16 per ton to erect, the most expensive part of which was driving the field rivets—the average price per rivet being about 25 cts.

The preservation of this steelwork is one of the most important considerations, inasmuch as it is constantly exposed to the corrosive action of the salt air, and, therefore, the Government required all the structural steelwork to be given a coat of the best red lead before leaving the shop, all contact surfaces an extra coat before assembling, and after erection two coats of dark green graphite paint. The corrugated galvanized iron was given two coats of graphite paint—the first dark green in color and the second slate.

To provide for the removal of coal, openings 2 ft. square are located with the lower edge flush with the floor at its lowest point and spaced 5 ft. apart on both sides of the shed. These are closed by means of guillotine valves, sliding in cast-steel guides and operated from a continuous runway extending the whole length of the building on both sides. Under this runway there has been built a trolley track, on which are movable chutes so arranged that coal may be delivered either on the deck of the vessel or on the deck of the pier. There are, therefore, 136 openings from which coal may be drawn.

With this plant and equipment four distinct operations are possible:

First.—Removal of coal from collier or barge or from railroad cars and delivery to the shed—thus securing means of storage.

Second.—The reverse of the above—thus allowing the transmittal of stored coal to other points in the navy yard or to a squadron lying in the outer harbor.

Third.—Removal of coal from the bottom of the bins and redistribution of it over the top—thus minimizing the danger of fire.

Fourth.—Removal of coal for coaling ships of war of the United States Navy, which is the most important operation of all.

Inasmuch as a part, and a comparatively large one, too, of the coal for a war vessel must be delivered to it in bags, the clear space on the pier, beneath the shed can be utilized for filling these bags in advance of the ship's arrival, this filling being accomplished by the reversing chutes. Then when the vessel is brought alongside all of the chutes on the bins adjacent to the vessel can be used for coaling directly or for filling deck buggies, etc., and the chutes on the opposite side for filling baskets to be transferred to the bunkers by a portion of the vessel's crew, who would also load the bags previously filled. By this carefully planned arrangement it is thought that 175 or 200 tons of coal per hour can be stowed in the bunkers of any vessel, which rate has never been nearly attained by the ordinary methods of coaling.

The construction of this plant was done by contract by Mr. Augustus Smith at a cost of $157,000; and under the efficient supervision of Civil Engineer R. C. Hollyday, U. S. N., in charge of the engineering work at the New York Navy Yard, the contract has been completed with as little delay as possible, and the fullest intent of the Government has been carried out, thus adding greatly to the defenses of the New York harbor by providing such a large storage depot for coal and such well planned means for delivering it to vessels.

THE NEW DESIGNS FOR THE MANHATTAN BRIDGE OVER THE EAST RIVER.

In our issue of July 7 we published perspective views of the new designs for the Manhattan Bridge with an explanation of the features of aesthetic design prepared by the architects, Messrs. Carrere & Hastings. These designs were submitted to the Municipal Art Commission of New York City as the law requires and were considered by that body at a meeting held on July 12. At that meeting criticisms of the designs were presented by Calvin Tomkins, Assoc. Am. Soc. C. E., President of the Municipal Art Society of New York and Jordan L. Mott of the Fine Arts Federation. Letters were submitted by Mr. Tomkins from Prof. J. Burkitt Webb of Stevens Institute and Prof. Wm. H. Burr of Columbia University. Extracts from these letters follow, Prof. Webb's being placed first:

The Brooklyn Bridge has shown that if such a structure be wanting in rigidity and strength its life will be short, and it is commonly known among engineers that this bridge will need rebuilding within a few years.

The principal weakness in the Brooklyn Bridge is in the so-called stiffening trusses, whose office is to prevent a wave motion of the floor. To correct this fault these trusses in the Williamsburgh Bridge were made 40 ft. high, and to this the unsightly appearance of the bridge is ascribed.

In the last design of the Manhattan Bridge as published, the stiffening trusses appear to have substantially the same height as in the Brooklyn Bridge, or not much over half the height of those in the Williamsburg Bridge. This has an important bearing upon the serviceableness, stability, and carrying capacity of the bridge under the vast and dense traffic which is expected to move across it, and no bridge is up to modern requirements whose design does not provide sufficent stiffness to prevent an injurious change if formed with different positions and arrangements of the moving load.

Prof. Burr wrote:

In view of the great magnitude of this work and of the importance to the city that it be done in such a manner to secure the highest excellence in design and execution, I recommend you to urge the Mayor to submit this design to the examination of a board of engineers equally eminent and qualified to that which passed upon previous plans of the same bridge. In making this recommendation there is no reflection whatever on the engineering organization of the Department of Bridges, of whose professional skill and ability I entertain no doubt, nor is it intended to trench upon the legitimate right of any Administration to revise reasonably the plans for public work to which it happens to fall heir. It is my judgment, however, that in the design and construction of so great a public work as this bridge, monumental in character, the technical work of the Department should be supplemented by deliberate and careful study of the best professional talent available. There is nothing new in such a procedure; it has already been followed in treating a prior set of designs for this bridge and for Blackwell's Island Bridge, and it is frequently followed in Europe for great public works. It is practically the only conclusive assurance that can be given to the public that all reasonable means have been exhausted to secure the best possible results.

Gustav Lindenthal, Mem. Soc. C. E., late Commissioner of Bridges of New York City, sent a letter to the Municipal Art Commission criticising the design as follows:

It is my professional opinion that if the bridge is built in accordance with the new plans it will be greatly inferior in rigidity to the plans already approved by you. The deflections and vibrations under the action of live load will be more than five times greater. In other words, the new design, while in point of rigidity better than the worn-out Brooklyn Bridge, would be greatly inferior in that respect to the Williamsburg Bridge, and still further inferior to the Blackwell's Island Bridge, and to the approved chain design for this bridge.

In the Williamsburg Bridge the stiffening trusses are 40 ft. high to provide the desired greater solidity. They spoil the appearance of the bridge. Beauty was here sacrificed to utility. I desired to avoid this mistake in the chain design. To that end the bracing, or stiffening, is attached to and below the chain, having the form of lace work, which in no way interferes with and rather enhances the aesthetic appearance of the bridge. If the same degree of rigidity were to be obtained with stiffening trusses their height would have to be 55 ft., or even 15 ft. higher than in the Williamsburg Bridge.

The result would have been an architectural monstrosity. It is evident that in the new design before you the stiffening trusses were made low for the sake of architectural appearance, and that utility was here sacrificed to aesthetics. But in doing so the design represents a retrogression to the inferior standards of 30 years ago. If it would save time or cost it might be excusable, but it does neither of these things.

The experience with the construction of the steel wire cables of the Williamsburg Bridge and elsewhere justifies the estimate of time required for construction to be from one and a half to two years longer than for the chain bridge. The latter can be completed under contract in three and a half to four years. This practically can be proved in four weeks by advertising for bids under the plans and specifications already prepared.

The form of anchorage in the plans before you does not permit of the utilization of the waste space inside of them in the practical manner shown in the anchorages for the approved chain design. The fine and imposing assembly halls, each larger than Carnegie Hall, and the auxiliary rooms, are left out. The yearly rentals of $25,000 to $30,000 obtainable from them are lost to the city. That amount more than covers the cost of yearly painting of the bridge, and by that much reduces the cost of maintenance paid from taxes.

Moreover, estimating approximately the cost of the new cable design and the approved chain design, both proportioned on the same basis of live loads and unit stresses, it appears that the new design will cost more by $2,000,000. This additional cost is principally due to the wasteful form of the superstructure and the heavier anchorages resulting therefrom.

Disregarding other defective features, the comparison of the two designs can be summarized as follows:

An inferior degree of rigidity.

A longer time of construction by one and a half to two years.

A loss of yearly income by $30,000, and

A greater cost of construction by $2,000,000.

The objections which I raise affect the public interest so profoundly that they should not be passed over lightly. I beg to submit to your honorable commission the propriety of having before you from a board of disinterested bridge experts an authoritative expression upon the engineering features of both designs to aid you in arriving at a just decision of approval or disapproval covering the design for the entire structure.

As I understand it, the intention of the Greater New York Charter is that your approval of designs for bridges and other monumental structures is essential to their legality. Of necessity, this involves passing upon the design as a whole. So that, while the purely structural features may involve considerations of a technical engineering nature, unless you are advised by this disinterested competent authority that these features conform to the best engineering practice, and offer advantages superior to the design already approved, it would be impossible for you to approve the design as a whole.

Mr. Tomkins also advocated the submission of the designs to a commission of engineers. After the arguments had been presented Commissioner Best asked and received permission to withdraw the plans for two weeks, at the end of which time they will be resubmitted for consideration, accompanied by models.

DIFFICULTIES WITH HOT WATER AT THE SIMPLON TUNNEL WORKS.

Difficulties in constructing the Simplon Tunnel have been encountered, which bid fair to make the completion of this work a task of exceeding interest. On June 1 there remained 800 m. (2,624 ft.) of heading to be driven to connect the two ends. In regard to this work Mr. Charles R. King, from whose notes the articles on the Simplon Tunnel, published in Engineering News of August 13, 20 and 27, 1903, were prepared states that springs of hot water at the Swiss (north) end have compelled work to be discontinued, with the possibility that it will never be resumed. In this case all progress will depend upon the advance made from the Italian end. At present the rate of advance here is about 6 m. (19.7 ft.) per day. Presuming that this rate of progress were to be continued without interruption the boring would be completed in October of this year. One of the principal engineers states, however, that even if everything goes well the heading will not be completed before November and that the tunnel will not be completed to full section before April or May, 1905.

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The argument for stronger construction of railway passenger cars finds constantly renewed illustration in the record of railway accidents. Only a few months ago* the occurrence of a succession of unusually disastrous passenger wrecks led us to remark upon the great difference in resisting power between ordinary coaches and the heavy Pullman and mail cars, usually coupled together in trains without regard to their very unequal strengths. The subject was again and more practically argued in the recent paper of Mr. Wm. Forsyth on "The Use of Steel in Passenger-Car Construction."† And within the past fortnight two disastrous collisions furnish a further commentary on the same theme. The Erie wreck at Midvale, N. J., and the Chicago & Eastern Illinois wreck at Chicago Heights, Ill., are stories of excursion trains composed of ordinary light coaches, destroyed in collisions which would have done little damage to a train of vestibuled sleeping-cars or to a train of cars framed in steel as Mr. Forsyth advocates.

It is to be noted that telescoping and bodily crushing of the cars are represented by the two wrecks respectively. Telescoping occurs in most passenger wrecks of serious nature; the vertical-plane couplers seem to be insufficient to prevent it. It may be that, in the usual case, destruction begins with crushing of the car platforms, and that this nullifies the alining action of the couplers to the extent that the car platforms can slide over each other and tear through the unsubstantial upper framing. But even if the telescoping of cars is not chargeable directly to weakness of the underframe, certainly it is greatly facilitated thereby. It seems clear that stronger underframing is urgently required, preferably a steel girder framing designed on orthodox structural lines.

Following this the construction of the car body above the floor will call for attention. The question at once appears: Why should not steel framing be adopted here also? The behavior of steel gondola cars in freight wrecks speaks strongly for the value of a rigid and resistant car-body. These cars are thrown off the track, are piled upon each other, are battered and distorted, according to the violence of the accident; but they are not crushed to splinters as are passenger cars, nor are they telescoped. A box framed in steel, filled with passengers, would, even if thrown about and badly distorted, offer a much greater chance for life than does the wooden box of the present-day passenger car. Full plate construction such as is found in the steel gondola car, is no doubt out of the question for passenger cars. Equivalent strength may, however, be concentrated in an open framework suited to the purpose of the passenger car. Perhaps the inclined end-post of bridge construction, together with its valuable collision-strut, may be copied in the end portions of this framework; in any case, the means for securing both strong and suitable design will not be wanting.

The limitations of the steel freight car are evident enough. But they offer no argument against the introduction and universal adoption of steel-frame passenger cars. The fundamental difference between freight and passenger cars, the character of their contents, makes it impossible to raise parallel considerations of expediency or economy. If the freight car with its contents be totally destroyed, an exact allowance for the loss can be made in the railway company's books; the safety or destruction of a passenger car with its contents is a question more difficult to estimate in dollars and cents.

*April 14, 1904, p. 352.
†Engineering News of June 30, 1904, p. 608.

Is scale in steam boilers a benefit or an injury? That it is generally assumed to be the latter we are well aware, and there is no doubt, of course, that the scale which forms in boilers using hard water is a very great nuisance and one which involves large expense in caring for it. But suppose for the sake of argument that boilers were supplied with water absolutely free from mineral matter, let us say, with rain water or distilled water. Would not the troubles that would be experienced far exceed those that are now caused by scale? To put the question in another form, is not the scale which forms in a steam boiler fed with fairly pure water really a benefit in protecting the interior of the boiler from the rapid corrosion which would otherwise take place?

In another column of this issue we print a paper by Mr. M. E. Wells, chief boiler inspector of the Burlington & Missouri River R. R., in which the fact is pointed out that boiler tubes piled outdoors and exposed to the weather rust out faster than tubes inside a boiler. The statement is made by Mr. Wells that perfectly pure water is the most corrosive that is put inside a boiler, and finally he expresses the opinion that "Nature has provided incrusting matter in water that the inside of the sheets of boilers may be coated with a layer of it and thus be protected from oxidation."

So far as we are aware, this idea has never before been set forth in technical literature. We do not mean by this that the fact that boiler scale protects from corrosion has not been noted and put on record but that the general importance of scale in boilers as a protection and preservative has never been recognized by any of those who have studied steam boiler construction and written treatises upon it.

Very likely many engineers will question the soundness of Mr. Wells' statement above quoted; but there seems to us to be much evidence in its support. We know that boiler shells which have been in service for years when protected from external corrosion often show scarcely any diminution in thickness, whereas if the same material were immersed in a river or pond it would be rusted very rapidly. Again, practical experience has shown that boilers in which rain water alone is used have given trouble from internal corrosion, and it has been frequently ascribed to acid gases absorbed by the water from the air. But may not the true explanation be that no scale is deposited by such water to protect the metal surfaces?

The question may be asked of what practical benefit would be a general knowledge of the protective power of scale. One benefit might be the more intelligent care of boilers. Many large power plants are now using the same feed water over and over again by the use of surface condensers or cooling towers. There will usually be sufficient make-up water used in such plants to protect the boiler surfaces, yet there may be cases where internal corrosion is going on unknown to those in charge of the plant.

Another field that has never been exploited is the possible use of scale to protect other metal surfaces than boilers from corrosion. Anyone who has tried to remove calcium sulphate scale from boiler flues or stays knows with what tenacity it will often adhere. It might be practicable to treat various metal articles such as fence posts or water mains by immersing them in a closed tank containing a saturated solution of calcium sulphate and then partially evaporating the solution. Certainly the demand for better and more effective methods of protecting iron surfaces from corrosion is great enough to encourage experiments in this field.

New York city, as many of our readers will remember, requires the use of fireproofed wood in the finishing of buildings exceeding 150 ft. in height. An ordinance has passed the Board of Aldermen, and is now in the mayor's hands, amending the building code to require the use of fireproofed wood in all buildings over 75 ft. in height, and in all buildings used as public institutions over 35 ft. in height.

It is manifest that the enactment of such an ordinance would increase many-fold the use of fireproofed wood, so-called, provided it were enforced; but whether it would actually effect the increased safety to life and property that is claimed is open to question.

Wood may be treated with chemicals so as to become non-inflammable, undoubtedly; but, it is one thing to pass such an ordinance as that above outlined and another thing to have the wood that goes into the building actually made non-inflammable. In all matters connected with the building industry we must face conditions as they actually exist. A large proportion of the building in New York city, as we have recently pointed out, is carried on as a speculative enterprise. The builders erect structures not to own but to sell, and looking solely to their profit on construction, they have a strong incentive to reduce cost at every point where it will not interfere with the appearance of a structure or its saleability. Now what will the speculative builder do if an ordinance is passed requiring the use of fireproofed wood in certain buildings? He will buy his fireproofed wood wherever he can get it cheapest, and there is pretty certain to be no lack of concerns offering "fireproofed" wood on the market at a very moderate advance over ordinary wood.

To thoroughly fireproof wood, heavy pressure and long time must be used in order to force enough chemical into the wood to have more than a superficial effect, but such a process is necessarily costly, whereas a superficial treatment can be quickly and cheaply given.

This is not a new question by any means. It was taken up by Building Commissioner Stewart and his Chief Engineer, Mr. W. W. Ewing, in the early part of Mayor Low's administration, and an earnest endeavor was made to formulate a series of tests for fireproofed wood so that only wood that had really been honestly treated should go into buildings where the law required it. With much difficulty the partial co-operation was secured of the companies engaged in wood fireproofing, and of expert chemists and engineers; but through lack of funds and support by the city authorities the attempt had little practical result. Until this work is done, however—until the Building Department is given the necessary data and authority to determine what is and what is not fireproofed wood, within the meaning of the ordinance, we see no prospect that the proposed compulsory extension of its use will be any real advance toward public safety.

Mayor McClellan might well refer the ordinance back to the Board of Aldermen with the suggestion that the whole matter of the compulsory use of fireproofed wood in building be investigated by an expert commission, which should advise the city what measures ought to be taken to safeguard both public and private interests.

The untimely death of Mayor Samuel M. Jones, of Toledo, O., removes a most remarkable and interesting figure from political and business life.

As most of our readers will remember, Mr. Jones became widely known as "Golden Rule Jones" through his public advocacy of the eleventh commandment as the proper rule for the conduct of all business, public and private. In his own factory at Toledo, Mr. Jones posted up prints of the Golden Rule, and would have no other shop rules whatever.

Only a few days since we received a copy of a new catalogue just issued by the company of which Mr. Jones was at the head, and the preface to the publication was evidently written by Mr. Jones himself, in all probability at no long time before his death. It is so much unlike the usual order of trade literature and is so expressive of Mr. Jones's own philosophy that we deem it well worth reprinting here:

Improvements follow each other in such rapid succession in the industrial world that only those who are truly wide awake can keep abreast of the times. Scarcely has a new invention or discovery been announced, or a new and so-called modern installation of machinery put in operation, before it is superceded by a still more modern one. In many fields of industrial activity, a machine or plant that was strictly up-to-date five years ago is today a back number.

Progress, if it is real, must be all around, inclusive. If we have better industrial conditions, if we have better machinery than we had 25 or 50 or 100 years ago, if we are better industrially, it follows of necessity that we are better socially, intellectually and politically; that is, that the social body, as a whole, the city, the state, the nation, is better, or else our progress is only seeming progress, not real.

The purport of all human effort is not alone the building of machines, the erection of great buildings, the creation of an abundant commerce, the construction of great railroad systems, but the final object of all of our efforts is, as everyone who stops to think must know, the production of a better and ever better kind of man and woman, a better average manhood.

No matter whether you believe this or not, you are probably an unconscious factor playing your part in this great drama. You can't do much good of any kind for yourself, even from the most selfish point of view, except as you do some good for your fellow man, and while you may go into "business" with no other thought in mind than that you are going after dollars, going to "make money," you will certainly fail, unless your business or enterprise is of such a kind that it is, in some way, a benefit to the community and the world of which you are a part and to which you look for patronage and support.

This is a brief statement of well known foundation principles governing human society. We recognize the Golden Rule, the law of "doing as you would be done by," as the most nearly scientific rule for the government of the relations of man that there is in written language. The Golden Rule is the law of action and re-action, as we find it in physics, expressed in morals. We get what we give. It is the law of give and take; of cause and consequence; of sowing and reaping, running through the entire warp and woof of all human experience.

In the conduct of our business, in the building of gas and gasoline engines, pumping powers, sucker rods, and oil well machinery, we have held to this principle, not because we lay any claim to a kind of goodness that is not common to all men, for "there is in every human being the germ of every human quality." The human instinct is to desire to do the right thing. We have tried to use good material and build good machinery, not alone because it pays, but because the soul finds delight in striving for perfection.

Another "community of interest" bond is announced between the electrical circles of Europe and America, in the shape of an agreement between the Crocker-Wheeler Co., and Brown, Boveri & Co., of Switzerland, whereby the former undertake the exploitation of the latter's alternating-current designs and inventions in this country. To the electrical fraternity it means a notable enlargement of the American alternating-current industry, hitherto concentrated in few hands. Good results in the way of even more rapid and more liberal development of this field than has already taken place may be naturally expected. But perhaps this is only of secondary interest. Primarily, the new affiliation takes rank with the other international alliances formed in the past year—notably that of the Allis-Chalmers Co. with Escher, Wyss & Co., and with the European steam-turbine interests—as an indication that the various countries are coming into closer industrial co-operation. International pooling of brains, by more effective means than were hitherto used, is recognized as advantageous. The exchange of ideas through the technical press, or by means of competitive imitation of designs, or by the "Studienreisen" so popular just at present in Germany, is slow and not always fruitful. On the other hand, direct commercial invasion of one country by another has numerous weak features. One of these is illustrated by another recent announcement: that the German branch of an important American manufacturing concern has in a few years sustained losses aggregating half its entire capital stock. But a co-operative combination which contemplates merely the pooling of ideas and designs of two concerns, each prosperous and successful in its own country, ought certainly to result in mutual benefit.

MACADAM VS. CONCRETE FOR A PAVEMENT WEARING COAT.

It has doubtless been a puzzle to many young engineers why concrete pavements have been so seldom built, particularly in view of the fact that cement walks have steadily grown in favor and in use. Elsewhere in this issue Mr. S. Whinery discusses the relative economy of concrete and macadam pavements, and comes to the conclusion that a 6-in. all-concrete pavement can be built at a price of $1.20 per sq. yd., including excavation and profit. The statement is then made that a first-class macadam pavement can not be built for much less, and would probably be less durable. A discussion of these two types of pavement may possibly draw out some hitherto unpublished facts, and, if not, may lead to tests that will demonstrate the soundness or unsoundness of the arguments in favor of an all-concrete pavement. In order that any tests may not be undertaken without a fuller consideration of the theoretical as well as practical objections to an all-concrete pavement, we purpose taking the other side of the question.

First, as to the probable durability of a concrete surface under traffic: the occasional exposure of concrete, due to the removal of an asphalt wearing coat, generally results in rapid crumbling away of the concrete wherever the traffic is so heavy as to make it impossible for all vehicles to turn aside. This it may be argued is due to the comparatively poor quality of the concrete, but let us not be too sure of that. It is also noticeable that where wheels cross cement sidewalks built of excellent material, a rapid crumbling occurs, generally beginning at the edge of the walk. The point to be considered, however, is that once the crumbling of concrete has begun it is practically impossible to stop it. To this it might be replied that a concrete patch applied soon after crumbling begins would be an effective preventive of further destruction. Unfortunately, this is not so. It is a peculiarity of concrete that the adhesion of new concrete to old concrete is very slight. This is well known, and Mr. Whinery recognizes the fact in his suggested specifications when he recommends the placing of the wearing coat upon the foundation before the concrete in the foundation has set. In the early days of cement sidewalk construction, many walks were failures, simply because the cement in the foundation was allowed to set before the wearing coat was laid.

In a word, therefore, concrete can not be patched successfully by applying a comparatively thin coat to a worn spot of old concrete. This it seems to us is a most serious objection.

On the other hand, macadam behaves in no such manner. It will "set" and "reset" indefinitely, because there is no chemical action in the process of "setting" or "binding." The surface may ravel badly after a long, spell of dry weather, but it knits again under the rolling of wheels after the next heavy rains. If it is desired to renew the stone that has been worn away, a 2-in. coat of new broken stone can be laid on the old, hard macadam surface, without even scratching the surface, and can be bound with screenings until a perfect and durable surface is secured. But if concrete were to wear down uniformly in a similar manner, who would undertake to put on a 2-in. layer to replace the material lost by wear?

In comparing the durability of concrete, brick, stone block and other pavements with macadam, it is customary to argue that because macadam may wear down, say, three times as rapidly as brick, for example, therefore the cost of maintenance of the macadam is three times as great as of brick. This reasoning is fallacious, because when the brick has worn down about 1 in. in thickness, it will be found to have worn to a wavy surface which necessitates the renewal of the entire pavement, thus causing a loss of some 3 ins. of brick over the whole area repaved. With macadam, however, all the material left in the pavement is available and valuable material, and needs but to be picked loose, harrowed and rolled to restore the surface at a comparatively slight cost. The same argument holds true in favor of macadam as against concrete.

In order, therefore, that concrete may compete successfully against macadam in point of maintenance cost, it must wear with almost perfect uniformity to a depth of several inches—a phenomenon that no one has ever observed and that few will dare predict.

In the matter of first cost, concrete may at times compare favorably with macadam, but wherever crushed stone can be bought for, say, $1.20 per cu. yd. (as assumed by Mr. Whinery), macadam can be laid at a profit for $3 per cu. yd., or for about 50 cts. per sq. yd. of macadam 6 ins. thick. The macadam pavements that cost $1 per sq. yd. will be found in most cases to be 10 or 12 ins. thick. There are absolutely no tests in existence to show the relative supporting power of a 6-in. macadam as compared with a 6-in. concrete; but we know by experience that a 6-in. macadam will be thick enough on probably three-fourths of the village streets in this country.

The factor that is responsible for the disfavor with which macadam is looked upon by many is the "cheap and dirty" way in which it has been laid in most of our village streets. The great majority of village streets in New Jersey, for example, have been laid with the very best stone in the world—trap—yet most of the macadam has been bound with clay and earth instead of with screenings. This practice is bad enough when the best stone is used, but it is disgraceful when a poorer quality of stone forms the wearing coat. Failure to understand how to make clean and durable macadam streets can hardly continue to exist much longer after such object lessons as are to be found in the country roads that have been built under the direction of the State Engineer in New York and under the Massachusetts Highway Commission in Massachusetts.

Right in New York City itself are scores of miles of trap-rock macadam in excellent condition, and but a few blocks away there are more miles in the poorest condition. The authorities have permitted the use of unfit binder, and what is worse, have apparently not made a study of economic methods of resurfacing by the use of the steam roller and the harrow. The streets are usually left for years until the surface becomes so worn and rough that a new coat of stone becomes necessary. Yet resurfacing can be done for 1½ cts. per sq. yd. if proper tools are used under proper direction, and it can be done with great rapidity. To wait, therefore, until it becomes necessary to supply new material is unnecessary, and tends to make it appear that macadam is in all cases expensive to maintain, even when it is not.

Whether we consider the first cost or the cost of maintenance, or both, it lies with the advocates of all-concrete pavements to present further arguments and data before it can be conceded that macadam is not the most economic pavement for village streets in those sections of this country where suitable broken stone may be had at moderate cost.

LETTERS TO THE EDITOR.

Superelevation in Deck-Bridges on Curves.

Sir: I should be greatly obliged if some of your correspondents would inform me as to what is considered the best practice in setting plate girder bridges on curves, on Eastern railroads. Is it customary to elevate the girders on the outside of the curve, using the same bracing as would be used for the girders if they were located

on a tangent, thereby throwing the webs of girders into an inclined position? Yours truly,

G. H. Holmes.

Cotter, Ark, July 11, 1904.

(We believe the usual practice is to set the girders level and plumb, getting the superelevation by blocking, notching the ties, or both. Confirmation or correction of this statement will be welcome.—Ed.)

A Home-Made Electric Light Blue-Print Machine.

Sir: During the past winter while the writer was temporarily residing in a small town in the northern part of Maine, it became necessary to make a quantity of large blue prints. As there was no large printing frame available, and as it was the season of year when in that climate the hours of sunshine are very limited, the apparatus shown in the accompanying photograph was devised. This consisted of a cylinder 18 ins. in diameter and 36 ins. long, which was made by sawing out three circular disks 1 in. thick and lagging them with strips of soft pine 1 in. wide and ¾-in. thick; through the center of this cylinder a hardwood shaft was inserted, projecting

A Home-Made Electric Blue-Printing Machine.

about six inches beyond each end. The cylinder was planed and then covered with one thickness of soft felt glued on. It was then placed on two wooden trestles, borrowed from the drafting room, and two 2,000 (nominal) candle-power electric arc lamps were hung a little above and about three feet away from the cylinder. The blue-print paper and the tracing were then stretched around the cylinder and fastened with thumb tacks, the lights were turned on and the cylinder revolved by means of a hand crank at one end of the shaft.

It was found that by using the special "Electric Light" blue-print paper excellent prints could be made in from five to seven minutes. The contact was perfect, all portions of prints as large as 36 x 50 ins. being perfectly sharp. The total cost of this particular outfit was $2.75, exclusive of the electric lights, which were borrowed from the local lighting company.

As the results obtained were so satisfactory I thought perhaps that the above description might be of use to some of your readers. J. A. Leonard.

467 West 23d St., New York City, June 23, 1904.

Concerning the Salaries of Engineers.

Sir: While reading over articles in Engineering News on the salary of engineers I have often wondered why something in the line of your editorial of June 16 was never written.

The matter appears to be a family trouble and engineers can blame members of their own profession for the present low salaries.

An engineer's time on any one piece of work is usually rather limited so that he must always be thinking of the future. If he has charge of the work he is naturally very anxious to make as good a showing for himself as possible and is usually no more averse to getting good assistants at low prices than he is to getting good labor or good material at low prices. Labor being protected by the "union" and material by the "Trust," about the only chance for the engineer to display his business astuteness is on the salary of his assistants.

The result is that the young engineer after spending three or four years in college has to spend the best years of his life working for about half what a union bricklayer gets.

There is no doubt but that a young engineer can well afford to work for honor or glory a certain length of time, but when he sees that he is up against it for life he had better join the hod carriers.

When the "executive engineer" gets charitable enough to think there are others in the world besides himself who have a right to live; when he is willing—or able—to make his reputation out of his own skin instead of some other fellow's there may be a chance for the beginners in the work.

For my part, I see no more harm in engineers organizing than in the hod carriers. If such a thing were really proposed it would no doubt be one of the executive engineers to first cry "unprofessional."

Yours very truly, M. W. T.

Bohio, Panama, July 5, 1904.

(We wonder whether our correspondent is prepared to adopt the strike, the boycott, the picket and the other methods of union labor. And if he is not, is he entirely sure that the unionizing of the engineering profession would raise engineers' salaries? Is not the real reason for low salaries of engineers the fact that the supply of engineers is greater than the demand? If this is the case—if there are a goodly number of competent applicants for every vacancy—what could a union do to alter the situation without adopting the methods of other unions?

On the other hand, many engineers to-day receive large compensation for their professional services because their work is considered eminently valuable by those who employ them. How long would such compensation continue if the engineer of his own motion forfeited his professional standing and deliberately placed his own work in the same class with that of the worker at a trade?—Ed.)

A Suggestion that Vessels be Equipped with Sprinkler Systems to Prevent Fires.

Sir: Your editorial of June 23 on the "General Slocum" disaster, has been read with appreciation, particularly the graphic manner in which you liken such vessels with their inflammable superstructures to frame buildings so frequently encountered in our fire insurance transactions.

In studying these buildings, applying fire protection to them, and watching the results for underwriting purposes, we have come to learn that there is but one method of preventing disastrous fires therein, and it is pleasing to note that that method is highly efficient in practically all instances.

Even if your timely suggestion for radically better planning and construction of vessels, tending to make them fire-resistive, should be carried out—which, we regret, is not at all likely—it is probable that existing craft would be allowed to remain for many years with but slight improvement. We, therefore, wish to urge that this time-tried efficent protection to land properties above referred to, namely, the automatic sprinkler system, be applied to our combustible passenger steamers. It is necessary that such fires be stopped at their point of origin, and almost immediately, by automatic action.

The sprinklers should be placed throughout every portion of the vessel, in compliance with the National rules and regulations. The water supplies should consist of the simple and well known pressure tank, one or more being employed, according to the individual requirements. These tanks are nothing more than boiler shells, two-thirds filled with water, under an air pressure of from 75 to 100 lbs. Under these conditions, air at 75 lbs. pressure would expel all of the water, the last leaving the tank under 15 lbs. pressure. These tanks need no elevation, and can be located anywhere in or on the vessel. A secondary supply of water should be secured from the boat's force pumps.

Craft used only during the summer excursion season would be equipped on the "wet pipe" system, with the water on all piping up to each sprinkler head. Those in service the entire year would be fitted with the "dry pipe" system, at least in those portions where freezing might occur. Such an arrangement is automatic and allows the water to flow upon the release of air from the sprinkler piping through an opened head. This system of protection would also serve as a most efficient alarm, as a valve would be installed which would give immediate notification of any flow of water through the piping.

It appears to us that a system of protection which has won its laurels in almost similar structures on land should virtually be made compulsory on these combustible vessels. The stopping of a fire at its inception by this method would prevent panic, and in fact, all but mere local knowledge of the existence of a fire.

Yours very truly,

Everett U. Crosby,

General Agent North British & Mercantile Insurance Co.

76 William St., New York, N. Y., July 11, 1904.

Notes and Queries.

L. L. D., Buffalo, N. Y., asks for data regarding the consumption of steam by steam whistles. The only experiments we recall on this matter have been made in connection with road tests of locomotives. A search through some of the published records of such tests would probably yield some information on this point.

G. A. H. desires to know what is the highest steel chimney stack in America. A stack at the Ridgewood pumping station of the Brooklyn water-works is 8 ft. in diameter, and 217 ft. in height, and has been claimed to be the highest steel chimney in the United States. The E. Keeler Co., of Williamsport, Pa., has just completed an 8 ft. steel stack 250 ft. in height to be erected in Mexico. We shall be pleased to hear from any of our readers who know of higher steel chimneys.

The article published in our issue of May 12, 1904, entitled a "Concrete Steel Highway Bridge at Plainwell, Mich.," by Mr. P. A. Courtright C. E., was previously printed in the "Michigan Engineer," the copyrighted proceedings of the Michigan Engineering Society, and was reprinted in our columns by special permission of that society.

STATISTICS OF RAILWAYS OF THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1903.

A summary of the figures of operation and equipment of the railways of the United States for the year ending June 30, 1903, has just been issued by the statistician of the Interstate Commerce Commission. The figures given cover mileage and capitalization, equipment, operating expenses and earnings and accidents. The following comprises the statistics which are of the most general interest to our readers:

MILEAGE OF RAILWAYS.

The total single-track railway mileage in the United States on June 30, 1903, was 207,977 miles, having increased 5,505 miles in the year ending on that date. This increase exceeds that of any previous year since 1890.

The aggregate length of railway mileage, including tracks of all kinds, was 283,821 miles, being classified as follows: Single track, 205,313 miles; second track, 14,681 miles; third track, 1,303 miles; fourth track, 963 miles; and yard track and sidings, 61,560 miles. There was an increase of 9,626 miles in the aggregate length of all tracks, of which 3,339 miles, or 34.69%, were due to the extension of yard track and sidings.

EQUIPMENT.

On June 30, 1903, there were in the service of the railways 43,871 locomotives, the increase being 2,646. As classified, these locomotives were: Passenger, 10,570; freight, 25,444; switching, 7,058. These were also 799 not assigned to any class. The total number of cars of all classes was 1,753,389, this total having increased 113,204 during the year. The assignment of this rolling stock was, to the passenger service, 38,140 cars; to the freight service, 1,653,782 cars; the remaining 61,467 cars being those employed directly by the railways in their own service. The average number of locomotives per 1,000 miles of line was 214, showing an increase of 8. The average number of cars per 1,000 miles of line was 8,540, showing an increase of 345 as compared with the previous year. The number of passenger-miles per passenger locomotive was 1,978,786, showing an increase of 70,476 miles. The number of ton-miles per freight locomotive was 6,807,981, showing an increase of 141,482 miles as compared with June 30, 1902.

The aggregate number of locomotives and cars in the service of the railways was 1,797,260. Of this number 1,462,259 were fitted with train brakes, indicating an increase during the year of 155,414, and 1,770,558 were fitted with automatic couplers, indicating an increase of 122,028. Practically all locomotives and cars in passenger service had train brakes, and of the 10,570 locomotives in that service, 10,110 were fitted with automatic couplers. Only a few cars in passenger service were without automatic couplers. With respect to freight equipment it appears that most of the freight locomotives had train brakes and 98% of them automatic couplers. Of 1,653,782 cars in freight service on June 30, 1903, 1,352,123 had train brakes and 1,632,330 automatic couplers.

EMPLOYEES.

The number of persons on the pay rolls of the railways in the United States, as returned for June 30, 1903, was 1,312,537, or 639 per 100 miles of line. These figures, when compared with corresponding ones for the year 1902, show an increase of 45 per 100 miles of line. The classification of employees includes enginemen, 52,993; firemen, 56,041; conductors, 39,741, and other trainmen, 104,885. There were 49,961 switch tenders, crossing tenders, and watchmen. With regard to the four general divisions of railway employment it appears that general administration required the service of 45,222 employees; maintenance of way and structures, 433,648 employees; maintenance of equipment, 253,889 employees; and conducting transportation, 576,881 employees. This statement disregards

a few employees of which no assignment was made. The amount of wages and salaries paid to employees during the year ending June 30, 1903, as reported, was $757,321,415; but this amount, as compared with the total reported for the year 1902, is understated for want of returns by $18,000,000 at least.

CAPITALIZATION OF RAILWAY PROPERTY.

The par value of the amount of railway capital outstanding on June 30, 1903, was $12,599,990,258, which represents a capitalization of $63,186 per mile for the railways in the United States. Of this capital, $6,155,559,632 existed as stock, and the remaining part, $6,444,431,226 as fund debt. Current liabilities are not included in railway capital. Current liabilities for the year amounted to $864,552,960, or $4,211 per mile of line.

Of the total capital stock outstanding, 43.94%, paid no dividends. The amount of dividends declared during the year was 5.70% on dividend-paying stock. Of the total amount of stock outstanding, 6.59% paid from 1 to 4%; 13.51% from 4 to 5%; 10.34% from 5 to 6%; 11.39% from 6 to 7%, and 9.10% from 7 to 8%. The amount of funded debt (omitting equipment trust obligations) that paid no interest was 4.33%. Of mortgage bonds, 3.58%, of miscellaneous obligations, 1.15%, and of income bonds, 30.39%, paid no interest.

PUBLIC SERVICE OF RAILWAYS.

The number of passengers reported as carried by the railways in the year ending June 30, 1903, was 694,891,535, indicating an increase of 45,013,030 as compared with the year ending June 30, 1902. The passenger-mileage, or the number of passengers carried 1 mile was 20,915,763,881, having increased 1,225,826,261.

The number of tons of freight reported as carried (including freight received from connecting roads and other carriers) was 1,304,394,323, which exceeds the tonnage of the previous year by 104,078,536 tons. The ton-mileage, or the number of tons carried 1 mile, was 173,222,278,993, the increase being 15,932,908,940. The number of tons carried 1 mile per mile of line was 855,447, which figures indicate an increase in the density of freight traffic of 62,096 ton-miles per mile of line.

The average revenue per passenger per mile for the year mentioned was 2.006 cts., the average for the preceding year being 1.986 cts. The average revenue per ton per mile was 0.763 ct. This average for the preceding year was 0.757 ct. Earnings per train mile show an increase both for passenger and freight trains. The average cost of running a train 1 mile appears to have increased between 8 and 9 cts. The ratio of operating expenses to earnings, 66.16%, also increased in comparison with the preceding year, when it was 64.66%.

EARNINGS AND EXPENSES.

The gross earnings of the railways in the United States for the year were $1,900,846,907, being $174,466,640 greater than for the previous year. Their operating expenses were $1,257,538,852, or $141,290,105 more than in 1902. The following figures give gross earnings in detail, with increase or the decrease of the several items as compared with the previous year: Passenger revenue, $421,704,592—increase, $28,741,344; mail, $41,709,396—increase, $1,873,552; express, $38,331,964—increase, $4,078,505; other earnings from passenger service, $9,821,277—increase, $962,508; freight revenue, $1,338,020,026—increase, $130,791,181; other earnings from freight service, $4,467,025—decrease, $379,693; other earnings from operation, including unclassified items, $46,792,627—increase, $8,399,243. Gross earnings from operation per mile of line averaged $9,258, the corresponding average for the year 1902 being $633 less.

The operating expenses were assigned to the four general divisions of such expenses, as follows: Maintenance of way and structures, $266,421,774; maintenance of equipment, $240,429,742; conducting transportation, $702,509,818; general expenses, $47,767,497; undistributed, $409,571. Operating expenses were $6,125 per mile of line, having increased $548 per mile in comparison with the preceding year. Expenses for the year according to the 53 accounts prescribed in the official classification of these expenses, with the percentage of each item of the expenses as classified for the years 1897 to 1903.

The income from operation, or the net earnings, of the railways amounted to $643,308,055. This item, when compared with the net earnings of the year 1902, shows an increase of $33,176,535. Net earnings per mile for 1903 averaged $3,133; for 1902, $3,048, and for 1901, $2,854. The amount of income obtained from other sources than operation was $205,687,480. The total income of the railways, $848,995,535—that is, the income from operation and from other sources—is the amount from which fixed charges and similar items of expenditure are deducted to ascertain the sum available for dividends. Deductions of such nature totalized $552,619,490, leaving $296,276,045 as the net income for the year available for dividends or surplus.

The amount of dividends declared during the year (including $420,400, other payments from net income) was $197,148,576, leaving as the surplus from the operations of the year ending June 30, 1903, $99,227,469, that of the previous year having been $94,855,088. The amount stated above for deductions from income, $552,619,490, comprises the following items: Salaries and maintenance of organization, $430,427; interest accrued on funded debt, $283,953,124; interest on current liabilities, $9,060,645; rents paid for lease of road, $112,230,384; taxes, $57,849,569; permanent improvements charged to income account, $41,948,183; other deductions, $47,147,158.

RAILWAY ACCIDENTS.

The statement of accidents to persons in the summaries in the statistical report under consideration are presented under the two general classes of accidents resulting from the movement of trains, locomotives, or cars, and of accidents arising from causes other than those resulting from the movement of trains, locomotives, or cars. These classes include all the casualties returned by the carriers in their annual reports to the Commission, whether sustained by passengers, employees, trespassers, or other persons, and for a number of reasons they are not in all respects comparable with others in the bulletins that are based on monthly reports.

The total number of casualties to persons on the railways for the year ending June 30, 1903, was 86,393, of which 9,840 represented the number of persons killed and 76,553 the number injured. Casualties occurred among three general classes of railway employees, as follows: Trainmen, 2,070 killed and 25,676 injured; switch tenders, crossing tenders, and watchmen, 283 killed, 2,352 injured; other employees, 1,253 killed, 32,453 injured. The casualties to employees coupling and uncoupling cars were, employees killed, 281; injured, 3,551. For the year 1902 the corresponding figures were, killed, 167; injured, 2,864. The casualties connected with coupling and uncoupling care are assigned as follows: Trainmen killed, 211; injured, 3,023; switch tenders, crossing tenders, and watchmen killed, 57; injured, 416; other employees killed, 13; injured, 112.

The casualties due to falling from trains, locomotives, or cars in motion were: Trainmen killed, 440; injured, 4,191; switch tenders, crossing tenders, and watchmen killed, 39; injured, 461; other employees killed, 72; injured, 536. The casualties due to jumping on or off trains, locomotives, or cars in motion were: Trainmen killed, 101; injured, 3,133; switch tenders, crossing tenders, and watchmen killed, 15; injured, 279; other employees killed, 82; injured, 508. The casualties to the same three classes of employees in consequence of collisions and derailments were: Trainmen killed, 648; injured, 4,526; switch tenders, crossing tenders, and watchmen killed, 17; injured, 137; other employees killed, 128; injured, 743.

The number of passengers killed in the course of the year 1903 was 355, and the number injured 8,231. In the previous year 345 passengers were killed and 6,683 injured. There were 173 passengers killed and 4,584 injured because of collisions and derailments. The total number of persons, other than employees and passengers, killed was 5,879; injured, 7,841. These figures include the casualties to persons classed as trespassing, of whom 5,000 were killed and 5,079 were injured. The total number of casualties to persons other than employees from being struck by trains, locomotives, or cars, were 4,534 killed and 4,029 injured. The casualties of this class were as follows: At highway crossings, passengers killed, 3; injured, 7; other persons killed, 895; injured, 1,474; at stations, passengers killed, 24; injured, 108; other persons killed, 390; injured, 501; at other points along track, passengers killed, 8; injured, 14; other persons killed, 3,214; injured, 1,925. The ratios of casualties indicate that 1 employee in every 364 was killed, and 1 employee in every 22 was injured. With regard to trainmen—that is, enginemen, firemen, conductors, and other trainmen—it appears that one trainman was killed for every 123 employed and 1 was injured for every 10 employed.

One passenger was killed for every 1,957,441 carried, and 1 injured for every 84,424 carried. With respect to the number of miles traveled, however, the figures show that 58,917,645 passenger-miles were accomplished for each passenger killed, and 2,541,096 passenger-miles for each passenger injured.

ANOTHER SERIOUS WRECK of an excursion train occurred on July 13. A picnic train on the Chicago & Eastern Illinois Ry., bound for Chicago, was wrecked by running into the rear of a freight train standing on a side-track. Twenty persons were killed in the wreck.

THE REAR-END COLLISION at Midvale, N. J., on the Erie Ry., July 10, has been investigated by a coroner's jury. The accident is blamed on the signal operator and the back-flagman of the forward train. The latter went back only a few hundred feet, and kept his flag furled. The signal was out of adjustment, so that when set for stop it took a slanting instead of horizontal position. The engineer of the second train interpreted the signal to indicate clear, and applied brakes only when, on coming around a curve, he saw the forward train and its flagman.

A DAM FAILED at or near Scottdale, Pa., on Saturday night, July 17. It is reported that the dam, with a reservoir and pumping station, had just been completed by the Citizens' Water Co., that the pumping station was wrecked, and that crops were badly damaged by the escaping water.

A FAST LONG-DISTANCE RAILWAY RUN is reported from England on May 9, 1904. A mail train on the Great Western Ry. covered the distance between Plymouth and London, 246 miles, in 3 h. 47 min., or at the rate of 65 miles per hour maintained for nearly four hours.

THE TOTAL LOSS in the Baltimore conflagration of Feb. 7 is now set at $30,500,000. The General Loss Committee organized by the Underwriters has adjusted 3,788 separate claims, on which the total insurance paid was $29,074,358. There remain eleven claims to be settled, and it is estimated that 1,000 to 1,200 claims for minor losses were paid direct by the companies. These minor claims, however, are believed not to exceed $1,500,000 in their total amount.

THE TOTAL RECORD OF CASUALTIES in the "General Slocum" disaster of June 15 has been made up by the New York Police Department, and the following totals have been given out for publication:

Identified dead	897
Unidentified dead	61
Missing	62
Injured	180
Escaped without injury	235
Number of adults dead	421
Number of children dead	476

This would indicate a total death roll in the disaster of 958.

DISINFECTION OF RAILWAY PASSENGER CARS with formaldehyde is regularly done on the Bavarian State Railways, at least in the case of first and second class cars. The system is to disinfect whenever a car comes into the shop for its regular inspection. The method used is to close all windows and doors tightly, place on the floor of the car a pan containing some metal weights heated to dark red, and pour in a 20% solution of formaldehyde. The car is kept closed for at least seven hours, and is then thoroughly ventilated. Tests have showed that a high degree of bactericidal action is secured. The cost of the disinfection is stated to be 3.6 Mark (90 cts.) per car.

THE NEW YORK RAPID TRANSIT RAILWAY will be opened for traffic as far north as 145th St. during the first week in September, according to a statement made to the Rapid Transit Commission by Mr. John B. McDonald, the general contractor. Everything will be ready, it is stated, to begin running experimental trains on August 1, and about a month will be required to train the train crews and to test out the signal system and other operating devices before throwing open the line to regular traffic. Practically no work remains to be done south of 145th St. except in finishing up stations. North of 145th St. the work is considerably behind, and these portions of the line will probably not be opened for traffic before next spring.

TWO ASSISTANT CIVIL ENGINEERS in the Navy are to be appointed in 1904. Under date of June 30 the Navy Department has issued the following list of rules regarding the examinations for these appointments:

No person shall be appointed who is less than 23 or more than 28 years of age.

Candidates for appointment shall be examined as to their physical fitness by a board of medical officers of the Navy and as to their mental and professional qualifications by a board of such officers as the Secretary of the Navy may designate for the purpose.

The physical examination shall precede the mental and professional, and if a candidate is found physically unfit for appointment he shall not be further examined.

Applications for permits to be examined must be made to the Secretary of the Navy, and must be accompanied by testimonials as to character, evidence of American citizenship, evidence of having received a degree in the civil engineering course of some professional institution of good repute, with a record of at least two years' practical experience as a civil engineer. No person shall be admitted who has been examined at any time within one year prior to the date of this examination and failed to meet the professional requirements.

The mental and professional examination will be competitive and in writing and will comprise such subjects as the following: Testimonials and adaptability; English grammar and composition; elementary physics; elementary geology; drawing; arithmetic; algebra; geometry; trigonometry; analytical geometry; differential and integral calculus; applied mathematics, including mechanics of solids and fluids and strains in structures; electricity; construction materials; engineering constructions, such as workshops, steam and electrical machinery; quay walls, wharves, sewers, yard railways, pavements, water distribution, foundations, etc.; surveying (topographical, trigonometrical, and hydrographical) and mapping; instruments, their use and adjustment.

Candidates who pass satisfactorily will be arranged by the board in the order of their relative merit as determined by such professional examination, and appointments will be made in such order, but no candidate will be considered as having passed a satisfactory examination, or be appointed, who does not attain a general average of 80%.

The examination will be held beginning August 1, 1904, at the Navy Yard, New York, N. Y., and candidates to whom permits may be issued should present themselves before the medical officer or board at that place at 10 o'clock a. m. on that date. The professional examination will occupy about ten days.